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This newsletter was entirely produced on a Macintosh using PageMaker and other related Macintosh software.

Printer Sharing on PCs

Terry Jones
tj@gpu.utcs.utoronto.ca

One of the more common questions we are asked, and one that hasn't been addressed in past ComputerNews articles, is how two or more computer users can share one printer.
On a Macintosh computer the answer is simple, use the built-in network. The answer on the PC is much more complicated.

There are three common ways to share printers: use a manual switch box, use an automatic switch box, or use a network. Most other techniques are really variations of these three.

A manual switch box is the first approach. It is by far the easiest to implement, the most straightforward in operation, and the least expensive to put in place. The switch box has connectors to which all the PCs and all the printers connect. On the front is a switch or a group of switches that allows you to manually select which printer is connected to a particular PC. (See *Figure 1*.)

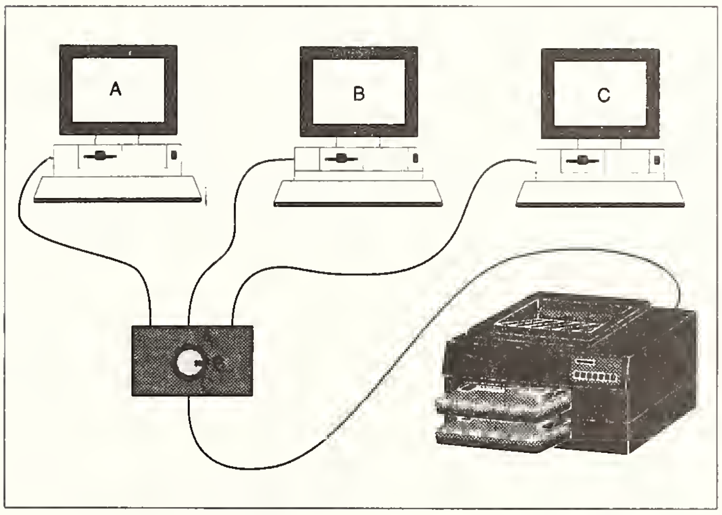
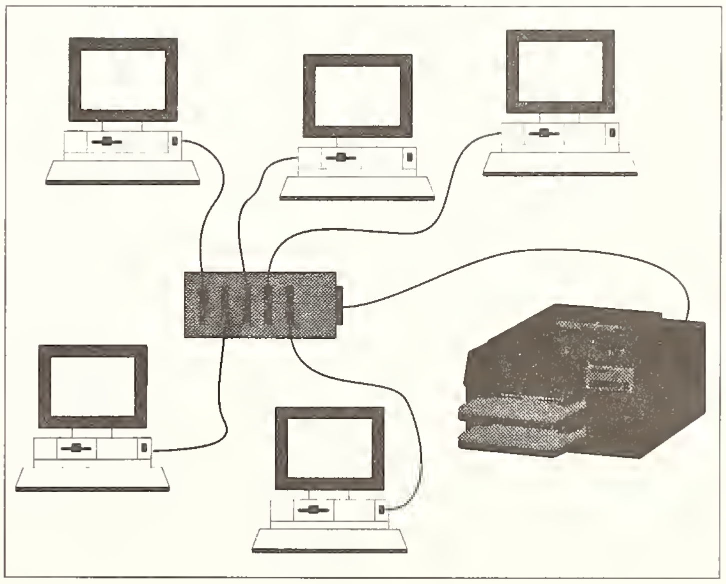


Figure 1: PCs sharing printer using a manual switch box.

The second technique is an automatic switch box. (See *Figure 2*.) In this approach, the switch box contains electronics that automatically monitor all of the PC ports for print data. When print data come to the box from a PC, the data are sent to the printer and the other PC ports are prevented from sending data at that time. In the simplest of this type of switch, the other PCs connected to the automatic switch box are told the printer is "not ready" while the first set of data prints, just as if the printer was turned off or was "OFFLINE." More elaborate automatic switches contain memory which is used to hold or "buffer" the other print data until the first PC is finished printing. In this approach, the printer always appears ready to

Figure 2: PCs sharing a printer via automatic switching device.



each user. The buffer also allows the switch box to accept the print data faster than the printer can print, thus freeing the PC from the printing task sooner than if it were printing directly to the printer. When the buffer memory is full, the switch will stop accepting print data until some of the buffer is emptied by data actually having been sent to the printer. Buffers of 256 kilobytes (KB) and 512KB (1/4 and 1/2 million characters) are quite common. These translate to about 100 and 200 pages of printed text.

A network is the third technique for sharing printers. This involves connecting the computers together to form a network. Some form of network adapter card is installed in each PC, and special network software is run when each machine starts. Network resources, such as disks and printers, can then be used in the same ways as printers and disks attached directly to your PC. Usually the printer will be attached to a dedicated PC on the network that acts as a server (see *Figure 3*). The other machines on the network send print data across the network to the server. Like an automatic switch with a large buffer, the server takes the print data from the PCs, stores the data on a hard disk, then sends the data to the printer. As long as the server has disk space, the network printer never looks "busy" to the PCs.

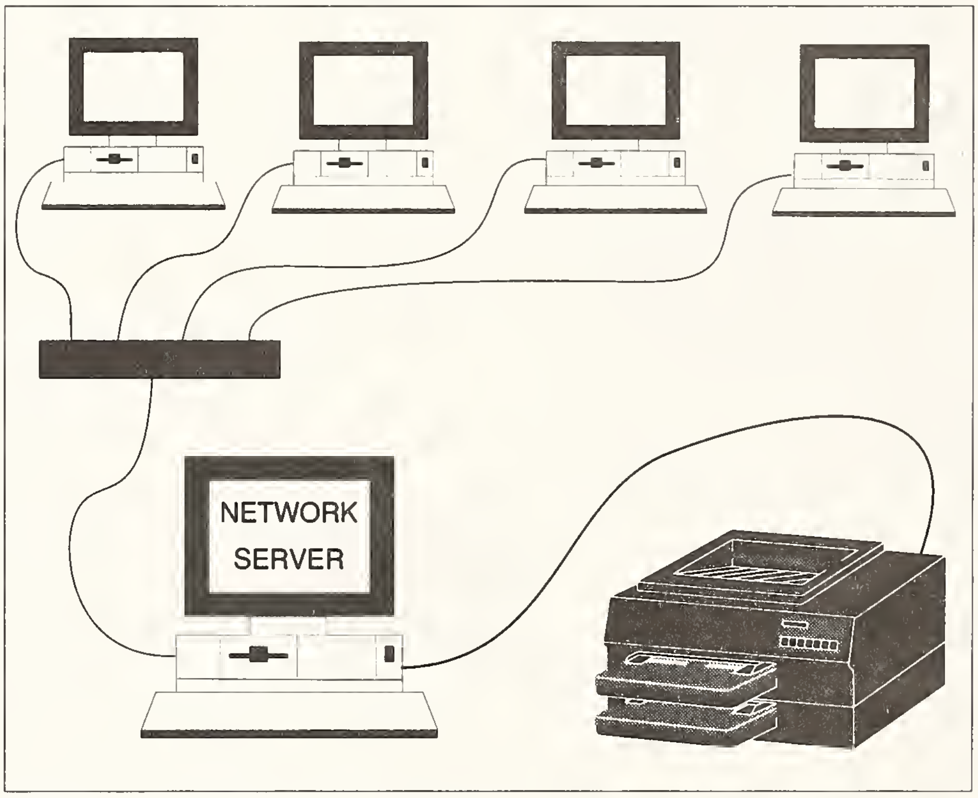


Figure 3: PCs connected together on a network accessing a network printer.

Advantages and Disadvantages

Each of these approaches has some significant advantages and disadvantages associated with it.

The manual switchbox is extremely simple to use, is easy to install, and usually costs in the $50 to $150 range. The weaknesses are that it is manual in nature and usually only is suitable for two to four computers sharing a printer. The people sharing the printer have to make sure that a co-worker isn't in the middle of a print job when they switch the printer to their PC. This usually means PCs must be physically close to each other so everybody can tell what the others are doing. It may be more time consuming because you have to walk over to the switch, turn it, walk back, and then print. Also, since you are directly connected to the printer, you can only print as fast as your printer can accept the print data.

An automatic switch box is a more convenient approach than the manual switchbox. Automatic switch boxes range in cost from about $150 for a device that lets six PCs share one printer, to $600 for six PCs sharing two printers with a 256KB buffer, right up to $1500 for elaborate multiple PC/multiple printer switches with huge buffers. The cost per PC can be relatively low in this approach, and the convenience can be high. Everyone connected to the switch box can print without worrying about what the others are doing. There are problems with this approach, however. The main problem is how the switch box determines exactly when one print job has ended before switching to the next print job. Usually this is accomplished by a timeout period. The switch box waits for more print data from the PC and if none comes for, say, 60 seconds, then the switch box assumes it has reached the end of the print job. The switch box then sends a new print job to the printer. This can be a problem in a number of ways. First, it means that at least 60 seconds has to pass between one job and another. A printer sitting idle for 60 seconds can be a significant waste of time. Second, a problem can occur when 60 seconds isn't long enough. If the PC sends the first page of print data, then does some calculations for two minutes before sending the second page, the switch box would decide the print job had ended and might start printing someone else's document.

Another example of this problem occurs when you ask to print just page 200 of a long document. Most word processing programs immediately send some initialization data to the printer, then search through the document for the page to print. It can often be longer than 60 seconds between the time when the initialization data are sent and when the print data for page 200 are sent. Because of the delay, the switch box would consider your job ended. This means that another print job could be sent in the middle of your printing, which might undo any initialization done for your job and result in unpredictable printouts. Many devices allow you to set the timeout period, but increasing this period increases the time wasted between jobs.

As mentioned earlier, automatic devices with memory buffers are advantageous because they can accept print data as fast as your PC can send it. They don't, however, eliminate the wait time caused by timeouts between jobs. (Usually the advantage of having your PC available sooner will outweigh the disadvantage of the timeout period.)

The network approach also has many attractive features, but has some drawbacks as well. Networks generally cost between $200 to $1000 per PC, in addition to the cost of a server PC. Obviously this is a high cost, but there are many more advantages to a network than just printer sharing. File sharing, electronic mail, access security, and sharing of other peripheral devices (fax, modems, scanners) are obvious benefits of having a network installed. There are also some features of network printing that switch boxes cannot offer; for example, banner pages can be generated to identify the owner of a print job, and multiple printer queues can be set for a single printer. This allows print jobs that are to be done on special paper or envelopes to be sent to one queue, while print jobs on regular paper go to another queue. The regular queue can be stopped, the appropriate paper placed in the printer, and the special paper queue started.

The end-of-job timeout problem associated with switch boxes can be avoided when using a network with "network aware" programs. When a word processing program understands it is sending data to a network printer, it can tell the network exactly when the print job ends. The next person's print job can start without delay. Most programs understand the common PC networks, but not all programs do. Those programs that don't are handled by the network, but usually in a similar fashion to automatic switch boxes with timeout periods.

A disadvantage of networks is their complexity. Usually they require a network administrator to maintain the server, configure the server, add users, and so on. Another drawback involves the network software that must be loaded at startup time on each PC attached to the network. This software can often use from 20KB to 200KB of Random Access Memory (RAM), making it difficult to run some of today's memory hungry applications. A further complexity is that certain network configurations can make it possible for both Macintosh computers and PCs to share the same printer. See the sidebar "Mixing Macintoshes and PCs for Printer Sharing."

Cabling: A Common Factor

Cabling is a common factor to consider in all three printer sharing techniques. All of the approaches require cabling to one extent or another. Cabling can easily cost as much as all the other hardware, depending on the type of installation. For three PCs in a small office, it may be possible to have a few cables running along the floor, but more often you must contend with desks and walls. Proper cabling, hidden in walls and ceilings, is expensive. The presence of asbestos in some University buildings can significantly increase the cost of cable installation.

The distances involved, and the type of communication between the PC and the printer or server, can determine which cabling technology can be used. The most common parallel printer cables and switching devices have an upper limit of 50 feet between the PC and the printer. Fifty feet isn't very long when you have to run cables around obstacles or into the ceiling. Some of the printer sharing techniques discussed above allow serial communications between the PC and the printer. Serial communication uses smaller cables and can be used over much longer devices, but are sometimes slower than parallel connections. Printers usually are parallel devices, so if serial communication is required for longer distances, the switching device must accept the serial data from the PC and send it in parallel to the printer. This usually increases the cost of the switching device somewhat. Networks usually work over quite long distances and operate at high speeds, but again, they can cost considerably more than manual or automatic switch boxes.

All of the above factors must be considered when trying to decide the answer to the simple question: "How can two or more computer users share one printer?".

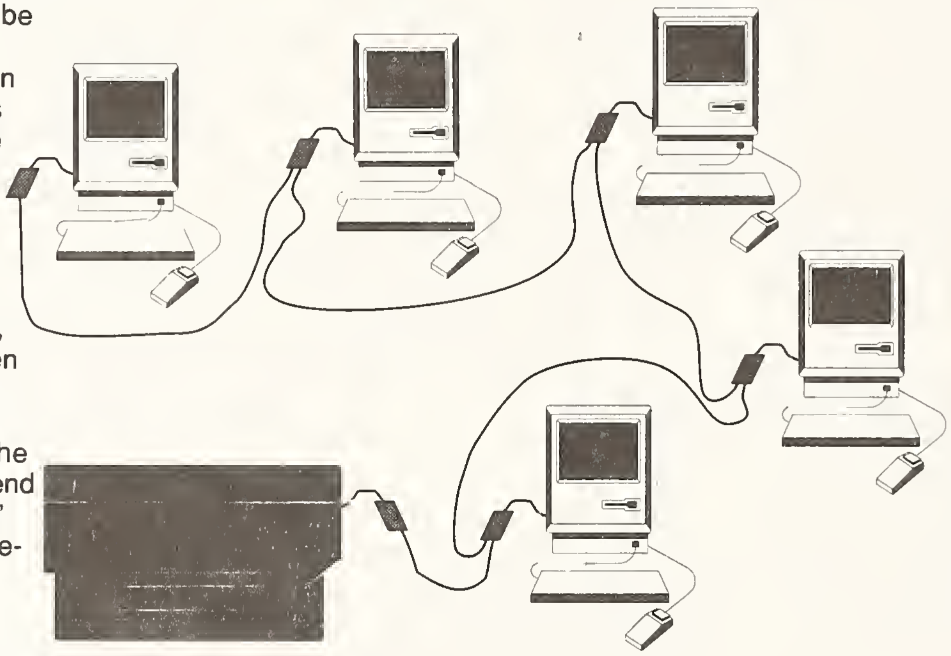
For more information contact Terry Jones at 978-4924 or Terry Sanderson at 978-4597.

Macintosh Printer Sharing

Apple Macintosh computers are easily able to share a printer. They have built-in network capabilities that allow them to be connected to an AppleTalk network. An external AppleTalk connector must be purchased (approximately $50) for each device to be connected to the AppleTalk network. This device plugs into the printer port on the back of the Macintosh and contains two cable ports. A cable runs from one of these ports to the next AppleTalk device. (AppleTalk devices may be Macintosh computers, printers, fax modems, network modems, or other devices.) AppleTalk devices are "daisy chained" together in this fashion, forming a network (see *Figure 4*). When sharing a printer over AppleTalk, your Mac will not be permitted to send print jobs if the printer is busy. As soon as the printer is not busy, the next Mac can send a print job. There is no "first in first out" queuing–the printer is available in a free-for-all fashion.

The printer to be shared must be an AppleTalk printer. Most PostScript printers are AppleTalk devices or have optional AppleTalk adapters available. Some low cost inkjet printers are AppleTalk devices as well.

Figure 4: Macintosh computers sharing a printer over AppleTalk network.



Mixing Macintoshes and PCs for Printer Sharing

There are a few different solutions to the problem of both Macintosh and MS–DOS computers sharing a printer or printers. Most of these are not simple.

You can put an AppleTalk network adapter card (approximately $200) in a PC. This makes the PC an AppleTalk device that can send print jobs over AppleTalk to the printer.

In a larger network it may be cost effective to use a gateway device between an AppleTalk network and a PC network. This gateway allows files and print jobs to be sent from one network to the other.

Recently, a simpler solution to this problem was provided by printer manufacturer QMS. Their QMS PS410 four-page-per-minute printer has both IBM parallel and AppleTalk ports on it, but unlike other printers of this type, both ports are active at the same time. The printer does automatic port arbitration (monitoring) so that when the printer is busy on AppleTalk, the PC users will wait, and when the PC parallel port is busy, the AppleTalk users will wait. The printer is shared on the Macintosh side using the AppleTalk network. On the PC side, the printer could be shared using one of the techniques described previously.

True Colour and Video on the Macintosh

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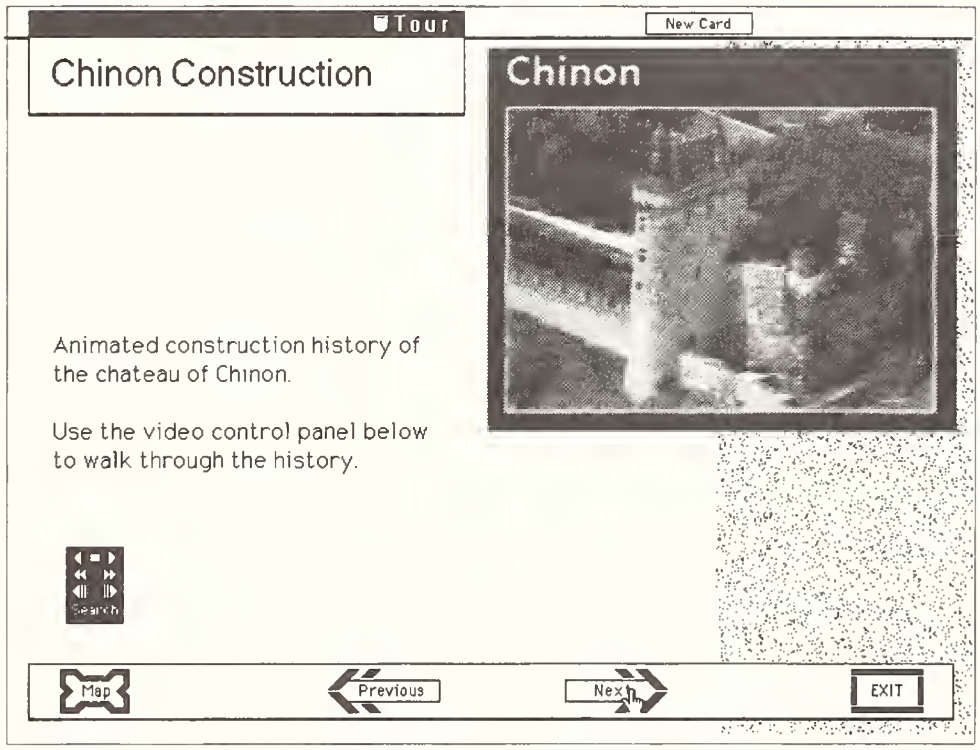
The number of features available on the RasterOps ColorBoard 364 makes it hard to come up with a short title that accurately describes this board. It is a 24-bit video adapter; it is a frame grabber or video capture adapter; it can display live video on your Macintosh screen; and, with options, you can use it to record your Macintosh screen on video tape or to watch TV while you work on your computer.

As a computer display video adapter, the RasterOps ColorBoard 364 is a good 24-bit NuBus adapter. It provides 16.7 million colours on the screen at once. Using the control panel, you select the number of colours your screen displays. You can choose colours or greys, and one of "Black and White", 4, 16, 256 or "Millions" of colours/greys to be displayed simultaneously. The more colours exhibited, the slower the display. In 256-colour mode, it is difficult to perceive any speed difference between the ColorBoard and the normal Macintosh colour adapter. In 24-bit mode (16.7 million colours), the adapter is noticeably slower. When using word-processing programs, you will probably switch to a mode with fewer colours for faster display. When using high-end graphics packages like Adobe Photoshop or Letraset's ColorStudio, the 24-bit mode provides "true" colour onscreen. Quite stunning computer displays are possible! In lower colour modes, the ColorBoard 364 adapter allows you to create a virtual desktop larger than the normal 640x480 pixels. You can then pan around this virtual desktop quickly. It isn't a full-page display, but it is better than the usual desktop.



Chinon Construction

Animated construction history of the chateau of Chinon.

Use the video control panel below to walk through the history.

Figure 1: Sample HyperCard 2 stack using live video onscreen.

The ColorBoard 364 is also a frame grabber. This means that you can hook up a video signal, such as your VCR or camcorder, and "capture" images from them. If you are capturing a moving image, the ColorBoard "freezes" the image as it captures it. You can capture a single image by pressing a key, or you can capture a sequence of images at specified time intervals. These images can be captured to Random Access Memory (RAM) or to disk. The number of images you can capture in a sequence is limited by the amount of RAM you have installed in your machine if you capture to memory, or the amount of free disk space you have when capturing to disk. Images captured to RAM can be saved on disk. RAM is much faster than disk, allowing very short intervals between captured frames.

Displaying live video on your Macintosh screen is one of the more exotic capabilities of the ColorBoard 364. A window of any size (up to the full screen size) can be created, and a video source, such as a VCR or camcorder plugged into the ColorBoard, will be displayed in that window. There are controls that allow you to zoom and pan, enabling you to select a small portion of the picture and enlarge it, or to shrink

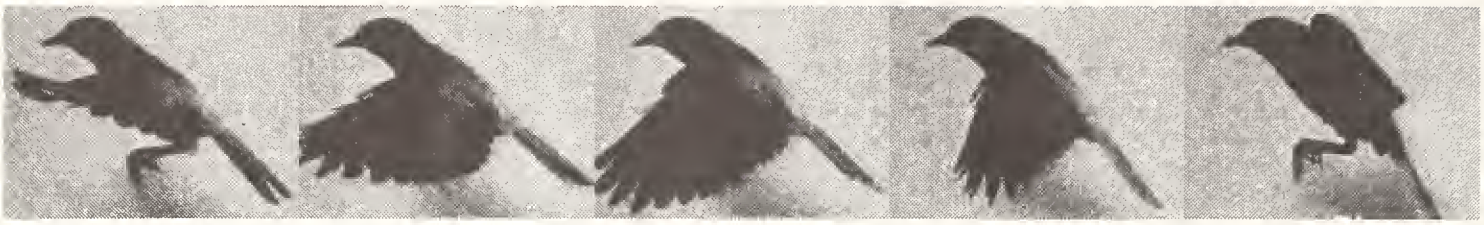


Figure 2: Sequence of timed captures from live video.

the entire window. This capability can be easily controlled from programs such as HyperCard and SuperCard. These programs use routines called external commands (XCMDs), which enable you to write, relatively easily, your own custom applications using live video on the Macintosh screen. One example of this is an Apple HyperCard 2.0 stack in the form of an interactive newspaper. Clicking on a front page headline takes you into the story or to live video relating to the story. The live video comes from a laser disc player that is directed by the computer to play selected segments of video at the appropriate time.

Options available for the ColorBoard include the Video Expander box and the Video Tuner box. The Video Expander allows you to record your Macintosh screen image onto video tape. If you are creating animations on your computer, you can use the Expander to make a video tape of your animation. It is also useful if you want to create training or demonstration tapes of how to use programs. The Expander box is compatible with some other video adapters, such as the Apple 8•24GC 24-bit graphics accelerator card. The Tuner option lets you tune in television stations so you can watch TV while you use your computer. The same can be done by plugging your VCR video output into the ColorBoard 364 and selecting the channel using the VCR.

The software provided with the ColorBoard 364 includes a desk accessory for displaying and capturing video, plus a FrameGrabber application that also lets you display and capture video, but gives you many more options and controls (like the multiple-timed captures mentioned previously). Also included are a RasterOps initialization resource (INIT), 32-bit QuickDraw (for older Macs), and HyperCard XCMDs for creating your own HyperCard stacks that take advantage of the card's video functions.

The card costs just over CDN$2000 from the U of T Computer Shop, making it suitable for higher-end applications involving video. The video expander option is just over CDN$500. If all you need is true colour onscreen, there are less expensive alternatives from RasterOps, Apple, and other vendors, that would be as good as, or at least faster than the ColorBoard for that application. The other features of the ColorBoard 364 make it relatively inexpensive when compared to boards with the same capabilities.

The ColorBoard is not without its weaknesses. It cannot overlay computer graphics on video (chromakeying)–RasterOps sells a higher-end product for this. The live video window is always "in front" of any other windows or graphics on screen (including the mouse pointer). The documentation is poor at present. The manual we received, dated March 1990 "Preliminary," contains basic operational information but no technical information. When we contacted the manufacturer in November, we were told that the updated documentation would be available "in a few weeks;" as of the middle of February 1991, it was still unavailable. The video expander adapter does produce recordable video but there are limitations, not all of which are problems with the expander. The first problem with the expander is overscan. We are used to TV pictures being overscanned so the edges of the picture are somewhere off the edges of the TV screen. Likewise, we are very used to seeing the edges of our computer screen. When using the expander, the edges of the computer screen are off the edges of the TV screen. This means that some of the top menu bar, some of the left and right edges of the window, and part of the trash can at the bottom disappear off the edges of the screen. The expander can be used with other adapters (Apple's 8•24GC) and some of these offer hardware or software solutions to the overscan problem. Another problem is that recorded computer screens with single-pixel-wide horizontal lines will flicker on the TV screen (due to a technical aspect of TV called interlacing). Preparing your computer screens without single-pixel horizontal lines will reduce this problem. Some software solutions are available, but other video adapters offer hardware solutions to this particular problem.

If you want to see the ColorBoard 364 in action or would like more information, please contact Terry Jones at 978-4924 or Geoffrey Rockwell at 978-4548.

RasterOps Update

Just before this issue went to print, RasterOps announced the 245TV board. Slightly lower in cost, it has apparently slightly higher functionality (e.g., chromakeying), with options for accelerators and compression adapters.

UTour:

An Interface for Educational Material at the University of Toronto

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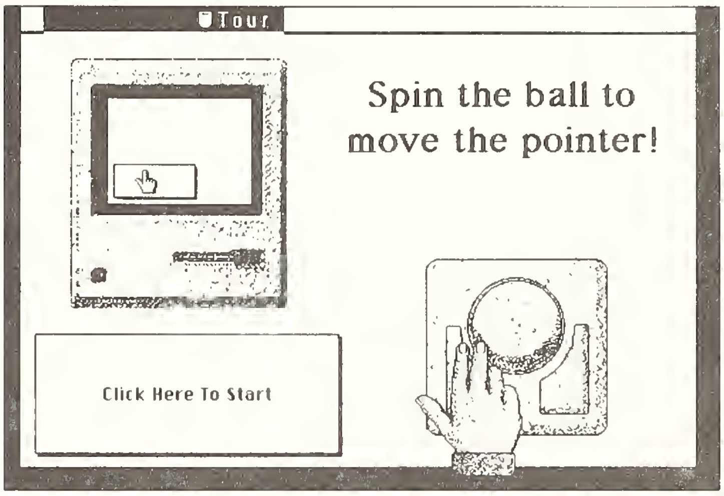


Spin the ball to move the pointer!

Figure 1: Opening card of MeMo stack. An animated sequence demonstrates to users how to use the track ball to move the cursor on the screen.

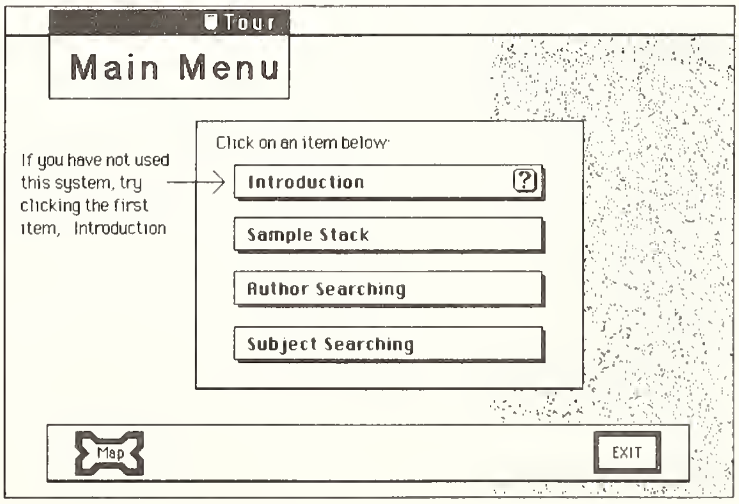
As authoring systems make it easier to develop educational material for computers, we can expect to see them proliferate. Students will be expected, more and more, to use such courseware. If each of these products looks and works differently, students will find they spend more time learning how to use computer materials than learning the subjects the materials are designed to teach. Unless standards are promoted now, while such material is relatively new, we can expect interface chaos on campus.

To this end, UTCS decided to create an interface standard called **UTour,** in conjunction with faculty from the Faculty of Library and Information Science (FLIS) and the University of Toronto Library. Because it makes more sense to develop an interface with a real task in mind, the UTour interface was initially developed for the Mental Models (MeMo) project which is on display in libraries across campus. MeMo is a system for learning about computerized card-catalogue systems like FELIX. (See March 1990 *ComputerNews.*) The UTour interface was initially developed in HyperCard, though it is by no means limited to HyperCard.

The challenge presented to the designers of the UTour interface was to develop something that people with no computer experience could walk up to and use. Hence, UTour is a walk-up-and-use or "kiosk" interface standard. It made sense to develop a kiosk interface first since it is the novice users who most need a standard and simple interface. The MeMo project for which the UTour interface was first designed also called for a kiosk system. Anyone who wants instruction can walk up to a MeMo station and browse the information without assistance from the otherwise busy librarians.

To make UTour accessible, we had to simplify the interface and teach you, the user, what you need to know as you go along. When you first encounter UTour, you see an animation that shows how rolling a trackball will move the pointer on the screen. The animation also invites you to click with your pointer on a

Figure 2: Main Menu card of MeMo stack.



Click on an item below:

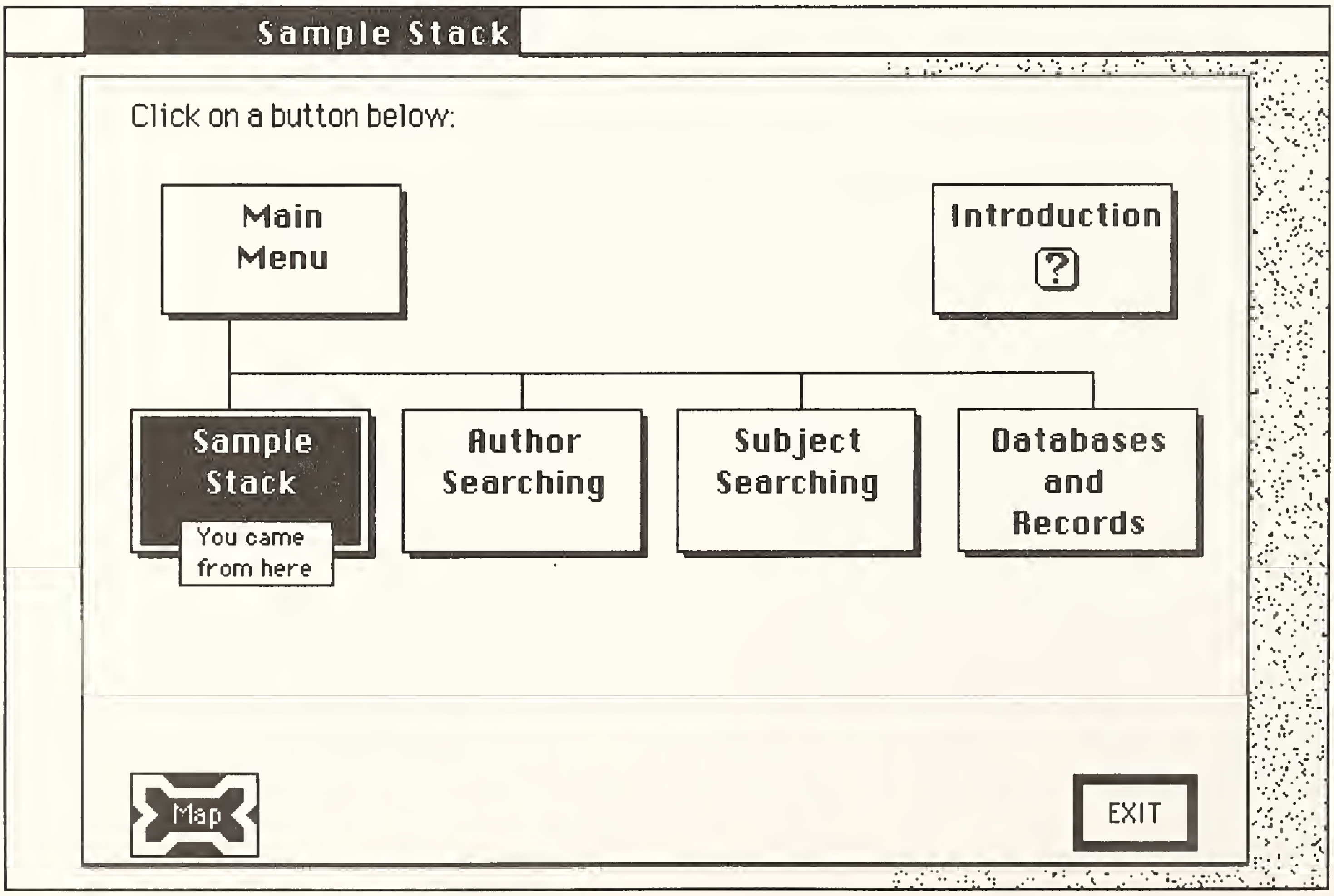
If you have not used this system, try clicking the first item, Introduction button that starts the system. Moving the pointer and clicking on buttons is the essence of the interface. The interface does not use special key combinations or pull-down menus, only buttons.

Once you enter the system, you are presented with a fixed menu of buttons, including a button that gives an introduction to the system. The introduction goes into greater detail about the interface. You learn about the control bar at the bottom of the screen that allows you to advance through lessons, go to a map of the system and, most importantly, exit the system. The Exit button is available everywhere so if you are lost or finished, you can easily end your session and reset the system to the initial animation. You are rewarded for this tidy impulse by the U of T mascot waving his paw and saying "Goodbye...". (An Italian version that says "Ciao" is in the works for students using the computer to learn Italian.) The system will also reset itself after a predetermined period of time if it is abandoned in mid-lesson.

One of the lessons we learned in the design of this interface was the importance of user-testing. Three different tests were run with the system to ensure that our intuitions were true. After each test we had to change things until the system became effectively easy to use. It was a humbling experience to discover that users did not think certain features were useful. For example, on the initial map design we had miniature pictures of the first card of each unit the map represented. The idea was that users could recognize places they had been and choose places they would like to go. While the users thought the map was cute, they did not think to click on the miniature pictures. We had to change the pictures to obvious buttons before the users recognized the interactive nature of the map.

Some of the other things touched upon by the UTour interface are: the layout of the screen, the animated transitions between modules (how to give users a sense of movement around the system), the fonts reserved for actions and instructions, the use of graphics, and the use of animations. We found that animating the material improves the chance that users will use the system and enjoy using it. If one creates the expectation of regular animations, users will go through the system in order to see them all. They will consider your system a treat, not educational drudgery. For this reason, we encourage developers to

Figure 3: Revised map design from the MeMo stack.



Click on a button below:

show their points with animation rather than ask the readers to read off the screen. To that end, we have a standard way of including short animations as part of UTour.

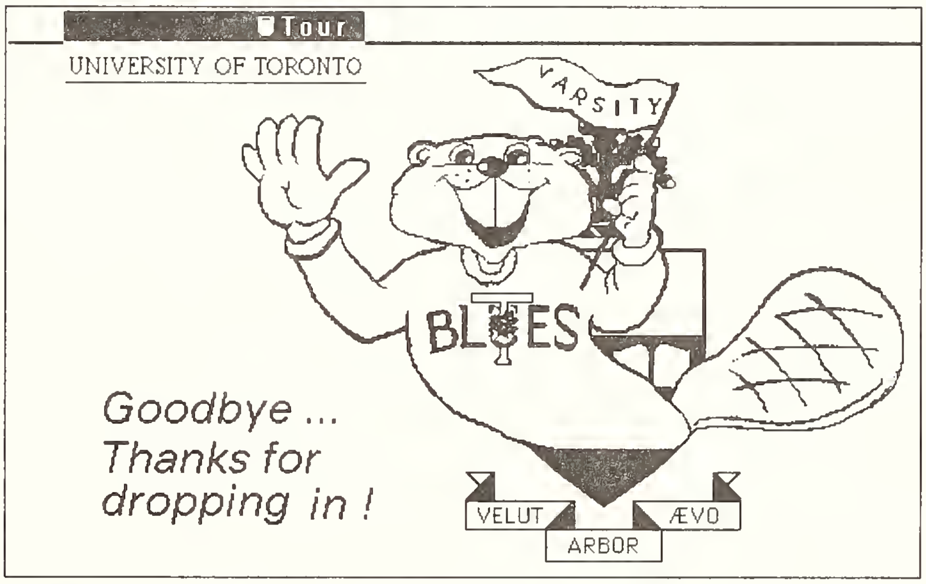
What is the future of UTour? Our primary goal is to encourage appropriate interface standardization on campus. The ideal would be a single interface capable of being adapted to different computers and different pedagogical needs. UTour is not such a standard, it is a start. Because of its history, it is only immediately applicable to educational material developed on the Macintosh for novice computer users. We hope people using HyperCard, or even other systems, to develop educational material will use the interface where appropriate. In cases where the interface is inappropriate, we hope developers will work with us to extend the interface. Such extensions will then be made available to others who follow in their footsteps. For example, Professor Wollesen of the Department of Fine Art is working to extend the interface so that it can be used for interactive art history lessons which make liberal use of colour images and, eventually, video.

We do not want developers to blindly follow the UTour standard. Those who are sensitive about design issues should view UTour as a point for discussion. If you do not think it is appropriate for your work, tell us–we are looking for real applications of the interface that will serve to improve it.

Some have not considered interface as an important issue in the development of educational material. We believe that the proliferation of designs already in evidence will distract from the pedagogic intent of the individual works. We want to encourage developers to be sensitive to interface issues and UTour gives us an example with which to begin. Because UTour is being used for a number of projects, developers may find it easier to adapt it than to design and test something from scratch.

For those who are interested, we have empty HyperCard stacks which can be used as templates for the development of new material. We can provide design advice by appointment. We can assist developers in testing their designs (whether or not the designs resemble UTour.) (We strongly recommend user testing before students are expected to use something.) Finally, we can put developers in contact with others working on similar design problems. Those who want to find out more can contact Geoffrey Rockwell at 978-4548.

Figure 4: U of T Mascot waves goodbye.



Goodbye ...
Thanks for
dropping in !

Reprints Available

Maureen Monné
monne@vm.utcs.utoronto.ca

Multimedia in education has become an item of considerable interest on the University of Toronto campus. Over the past year, we have featured many articles about presentation software, how to develop courseware, and multimedia in the classroom in *ComputerNews.*

We have compiled these articles as a collection of reprints, complete with the original artwork. If you would like to receive a copy, please call Maureen Monné at 978-4034. For technical advice about developing multimedia courseware, call Geoffrey Rockwell at 978-4548.

Producing the Perfect Paragraph:

Paragraph Alignment Tips for PC and Macintosh Users

Harriet Ji
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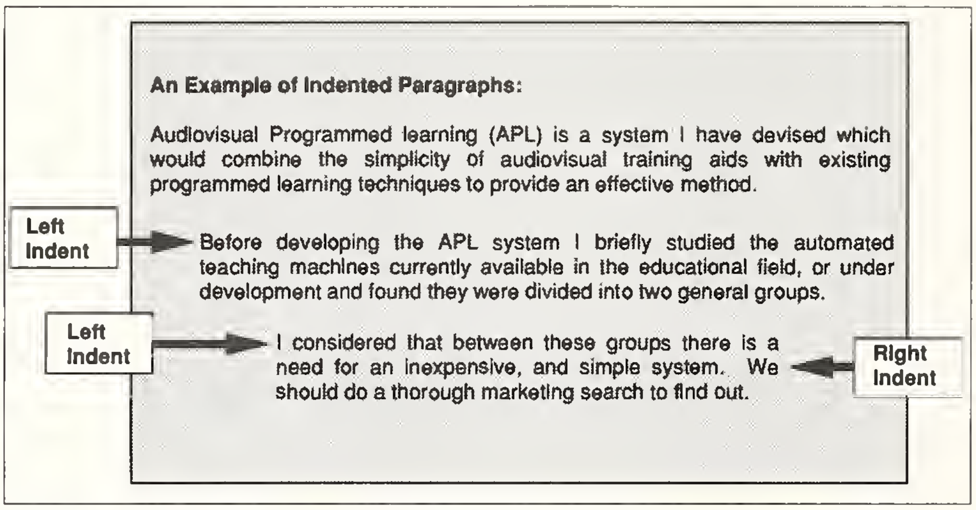
As a specialist in microcomputer word-processing packages at UTCS, I have often encountered frustrated users of WordPerfect or Microsoft Word who were upset to find their files "messed up" when trying to print on a laser printer. These users had wanted to give some paragraphs in their papers an indented look (see *Figure 1*). However, instead of using the "indent-paragraph" feature in their word processor, they spent much time placing tabs at the beginning of every line to give the paragraph an indented left margin (see *Figure 2*). When they printed the document on a laser printer, they found the tabs, originally placed at the beginning of lines, interspersed throughout these paragraphs (see *Figure 3*).



Left Indent
Left Indent
Right Indent

An Example of Indented Paragraphs:

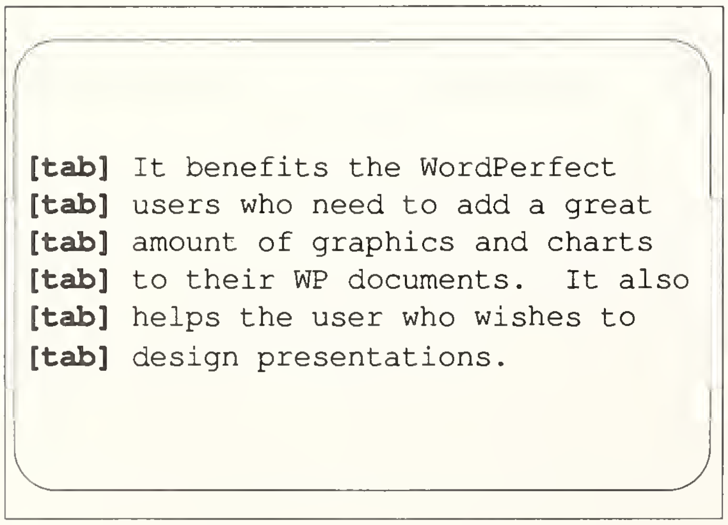
Audiovisual Programmed learning (APL) is a system I have devised which would combine the simplicity of audiovisual training aids with existing programmed learning techniques to provide an effective method.

Before developing the APL system I briefly studied the automated teaching machines currently available in the educational field, or under development and found they were divided into two general groups.

I considered that between these groups there is a need for an inexpensive, and simple system. We should do a thorough marketing search to find out.

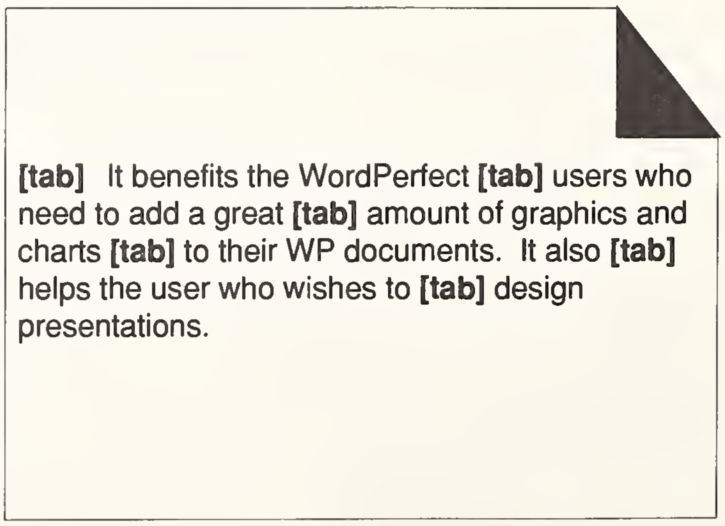
Figure 1: Sample of commonly-used indents. The left margin is indented in increments of one-half inch.

Figure 2: Using tabs to indent the left margin of your text looks fine onscreen.



```
[tab] It benefits the WordPerfect
[tab] users who need to add a great
[tab] amount of graphics and charts
[tab] to their WP documents.  It also
[tab] helps the user who wishes to
[tab] design presentations.
```

Figure 3: The printed version of Figure 2. Notice the random appearance of the tabs, rather than a consistent left margin indent.



[tab] It benefits the WordPerfect **[tab]** users who need to add a great **[tab]** amount of graphics and charts **[tab]** to their WP documents. It also **[tab]** helps the user who wishes to **[tab]** design presentations.

Desperate about the messed up paragraphs and the approaching deadline, the users asked why this could happen: "We have done nothing to the document. We spent hours writing and editing our papers, but look at what happens when we laser print. Where do these gaps between the words come from?"

Unfortunately, these users had made a common yet crucial mistake in using their word processors. They did not correctly create indented paragraphs while preparing their documents. To understand the nature of their mistake, it is necessary to have some basic knowledge of the three formatting tools used in all major word-processing packages on PC and Macintosh: the Space bar, the Tab, and the Indent-paragraph feature. There are major differences between the three. Briefly, the Space bar is used to enter one or more letter spaces only; the Tab is used to leave a certain width of space between words in a single line; and the Indent-paragraph feature is used to indent a paragraph of more than one line. Any mix-up of the three will cause troubles in your printing job sooner or later. In the following paragraphs, I will explain why the confusion of the three could mess up your printing and how you should indent the paragraphs correctly.

First of all, let's take a look at the difference between the Space bar and the Tab, and the problems caused if you neglect the difference. I find it useful here to remind the users of Ihor Prociuk's article "The Tab–Refining Your Alignment" (*ComputerNews*, March 1990, pages 15-18). In his article, Ihor wrote that it is important for a word processor user to form the habit of using the Tab key to enter the gap between two columns of indented text. However, many users still mistakenly use the Space bar for such a job. Although these spaced gaps look fine on your computer screen and may print well on your dot-matrix printer, you will have trouble when trying to print the file on a different printer, especially on a laser printer. Why? He gave the following points of explanation:

- In almost all word-processing packages, you should specify a font for your printing. If you do not select a font, a default font is used. In WordPerfect and Microsoft Word, the default font depends on the printer you use.
- There is a major difference between the proportional and fixed-width fonts provided by various printers. A proportional font has different "widths" for different characters. For example, the letter "i" doesn't occupy as much horizontal space as the letter "w." On the other hand, a fixed-width font has the same width for all characters, an "i" takes up as much horizontal space as the "w." So if you wrote your paper in a fixed-width font such as "Courier" and then changed to a proportional font such as "Times Roman," the altered width of the fonts will rejustify the number of characters and lines contained in one page in your document (see *Figure 4*, next page).
- Both WordPerfect and Microsoft Word for PCs use fixed-width fonts for their screen displays, so it is tempting to use the Space bar to enter the gap between two columns without knowing that the spaces might have different widths than the letters in proportional font printing.
- Once a proportional font is selected for printing, say Times Roman on a laser printer, the spaces between columns entered by the Space bar will print with different widths and cause an unaligned effect.

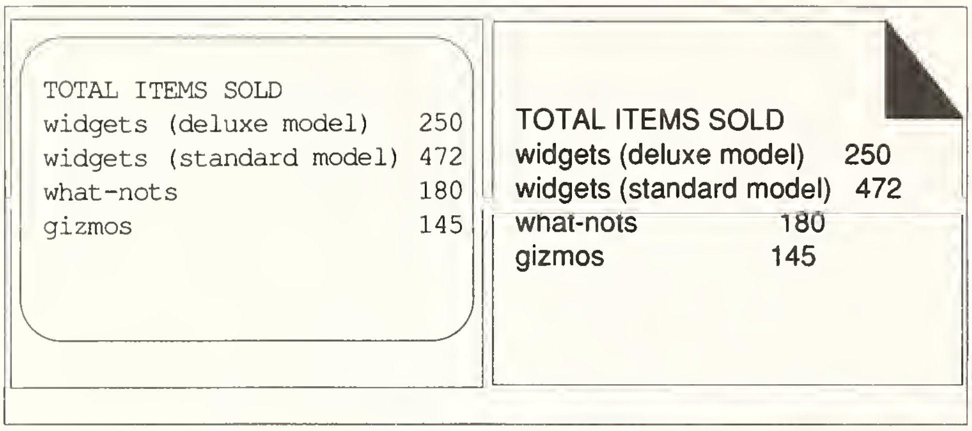
USE TABS for the gaps between columns or indented text in your word processor.

To avoid such a problem, concluded Ihor in his article, you should USE TABS for the gaps between columns of text in your word processor. Treated as a single character with a set length of space, the Tab will keep the gap unchanged no matter what fonts and printers you select for the document.

Now that you know why you must use the Tab, not the Space bar, in computer word-processing, let us take a look at the difference between the Tab and the Indent keys. We will see why there are situations where you must not use the Tab, but must use the Indent feature, to avoid possible trouble in your future printing.

First, the Tab works only for a single line, not for a paragraph of more than one line. It is okay if you just use the Tab to give a first line indent in a paragraph or leave a wide space between two words in the same line. However, you should not use the Tab to change the left margin of a paragraph.

The Indent (better called the Indent-paragraph feature) is the correct feature to indent any paragraph with more than one line of text. It will allow you to change the left and right margins of a specific paragraph, making it different from the rest of the text. For example, if you press <F4>, the



```
TOTAL ITEMS SOLD
widgets (deluxe model)   250
widgets (standard model) 472
what-nots                180
gizmos                   145
```

TOTAL ITEMS SOLD
widgets (deluxe model) 250
widgets (standard model) 472
what-nots 180
gizmos 145

Figure 4: Using the space bar to line up your text using a fixed-width font looks great onscreen (left), but when you print using a proportional font you lose the alignment (right).

left-indent key in WordPerfect, by default it will move the whole paragraph one-half inch to the right each time (see *Figure 5* bottom left).

With a correctly-indented paragraph, you can freely insert or delete any number of characters, select different fonts or type sizes, and alter the margins and page sizes of the document. The paragraph will automatically wrap its lines of text within the indented left margin no matter how you alter the environment (see *Figure 5* bottom right).

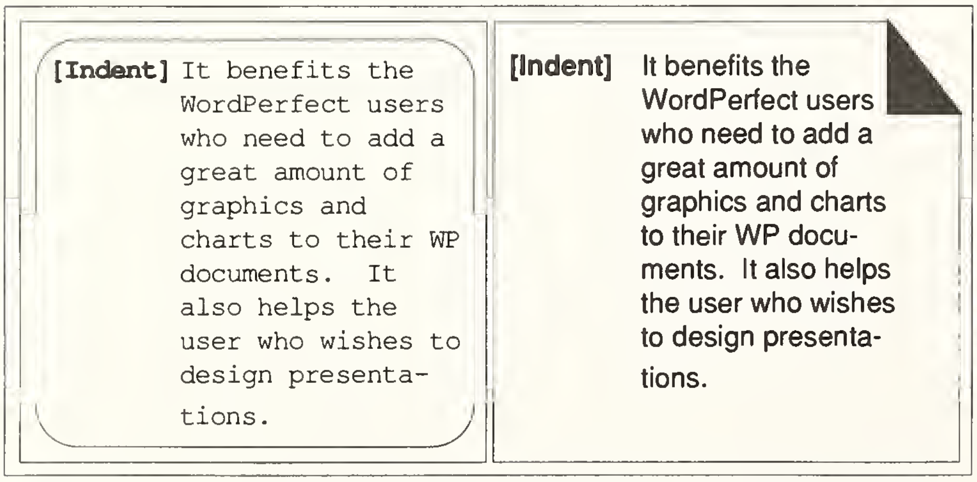
Now it is easy for us to see why the upset users I mentioned in the beginning of this article found their files messed up when trying to print on a laser printer. The computer did not know that the tabs were used for left margin indenting. It just reorganized the lines in each page and changed the line ends. The position of tabs in the beginning of lines were changed too. If they kept using the fixed-width font for screen display and printing, on a dot-matrix printer for instance, they wouldn't notice the problem. However, once they changed from a fixed-width font to a proportional one on a laser printer, the changed width of characters would also rejustify the text lines and push the tabs everywhere in the paragraphs. So by neglecting the major difference between the Tab and the Indent feature, you will face this tab problem sooner or later in laser printing.

To save trouble and avoid unnecessary frustration in the future, please remember these three simple points:

1 The Space bar enters a single letter space; the Tab key enters a certain width of space in a single line of text; the Indent feature works for a multi-line paragraph.

2 PC computer screens and dot-matrix printers generally use fixed-width fonts, while laser printers provide proportional fonts that differ from the former in their character widths. When moving from one to the other, you should expect re-adjustment of text lines in your document.

3 Never use the Tab to indent the left margin of a paragraph with multiple lines. Use the Indent-paragraph feature.



```
[Indent] It benefits the
         WordPerfect users
         who need to add a
         great amount of
         graphics and
         charts to their WP
         documents.  It
         also helps the
         user who wishes to
         design presenta-
         tions.
```

[Indent] It benefits the WordPerfect users who need to add a great amount of graphics and charts to their WP documents. It also helps the user who wishes to design presentations.

Figure 5: Screen version of a properly-indented paragraph, using a fixed-width font (left). When indents are used properly, printouts are correct every time (right)!

Instructions for Correctly Indenting Paragraphs

In WordPerfect 5.0 or 5.1:

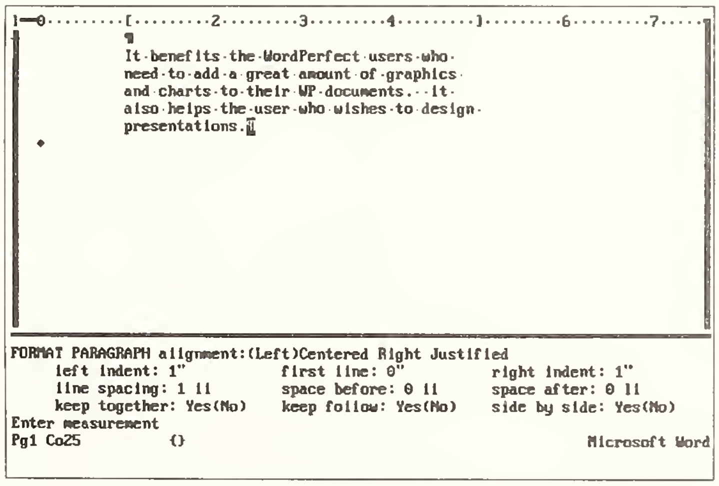
1. Before typing a paragraph (or at the beginning of the paragraph if it is already typed), press <F4> to give a half-inch indent to the right. (If you want to indent a paragraph, a quotation for example, on both the left and right margins, press <Shift><F4>.)
2. Move the cursor down across the indented paragraph to display the effect in the screen. In the Reveal Codes screen (<Alt><F3>), you will see an [->Indent] or [-> Indent<-] code placed at the beginning of the indented paragraph. Delete the code if you want to remove the indent feature.

In Microsoft Word on PC:

1. Before typing a paragraph (or anywhere in the paragraph if it is already typed), press <Esc>, Format, Paragraph.
2. In the FORMAT PARAGRAPH alignment menu, type 0.5" (or 1" or 1.5" according to your needs) in the "Left Indent" field. (See *Figure 6.*)
3. Press <Enter> to carry out the command. If you want to cancel the feature, change the value back to 0" in the Left Indent field in the Format Paragraph menu.

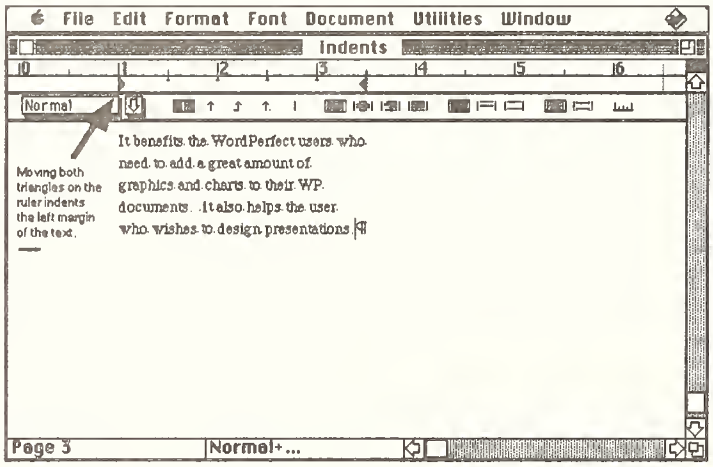
In Microsoft Word on Macintosh:

1. Before typing a paragraph (or anywhere in the paragraph if it is already typed), click on Format, Show Ruler to display the ruler in your screen.
2. Click to position the Insertion point within the paragraph.
3. Drag the left margin triangles to the right, to the place where you want the left margin of the paragraph to be indented (see *Figure 7*).
4. Move the triangles back if you want to cancel the indent feature.



```
1—0·········[·········2·········3·········4·········]·········6·········7·····
            ¶
            It·benefits·the·WordPerfect·users·who·
            need·to·add·a·great·amount·of·graphics·
            and·charts·to·their·WP·documents.··It·
            also·helps·the·user·who·wishes·to·design·
            presentations.¶
FORMAT PARAGRAPH alignment:(Left)Centered Right Justified
     left indent: 1"          first line: 0"          right indent: 1"
     line spacing: 1 li       space before: 0 li      space after: 0 li
     keep together: Yes(No)   keep follow: Yes(No)    side by side: Yes(No)
Enter measurement
Pg1 Co25         {}                                            Microsoft Word
```

Figure 6: The Format Paragraph menu of Microsoft Word on the PC.



It benefits the WordPerfect users who need to add a great amount of graphics and charts to their WP documents. It also helps the user who wishes to design presentations.¶

Moving both triangles on the ruler indents the left margin of the text.

Figure 7: Ruler showing triangles used to indent left margin in Microsoft Word on the Mac.

Macworld Expo 1991, San Francisco

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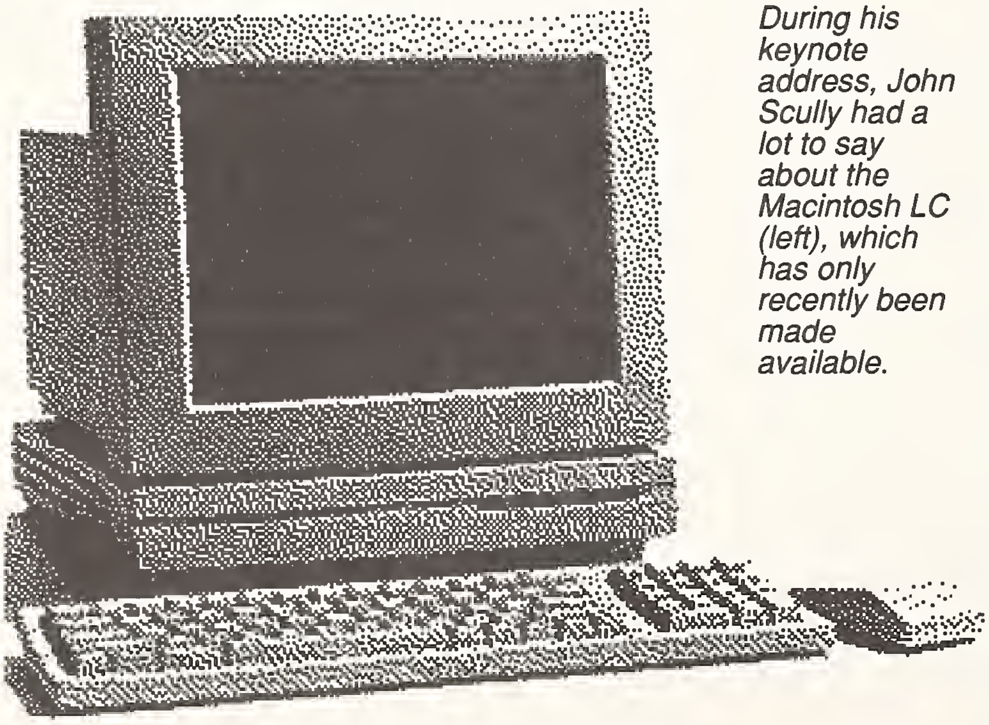
For many Macintosh enthusiasts, the event of the year is the annual pilgrimage to the Macworld Exposition in San Francisco. This show attracts a large number and variety of vendors, especially because so many Macintosh hardware and software developers are located in California. This year, 500 companies exhibited their wares and 60,000 people came to look at them. There were over 300,000 square feet of exhibit space.

John Scully, the Chief Executive Officer of Apple Computer, delivered the opening session keynote address. He offered interesting insights into Apple's future computing and networking strategy for education. Many of us from the university environment appreciated the fact that Apple reaffirmed its commitment to higher education and to the Kindergarten to Grade 12 market. In the sessions that followed there were many speakers from different universities talking about Macintosh computers at their campuses.

The Advising and Application Support group at UTCS, to which I belong, concentrates on (among other things) the evaluation, recommendation, and investigation of networking, communications, and electronic mail solutions for personal computers. As a result, I spent most of my time in sessions and with vendors dedicated to this area. However, I have not excluded other particularly interesting uses of the Macintosh computer.



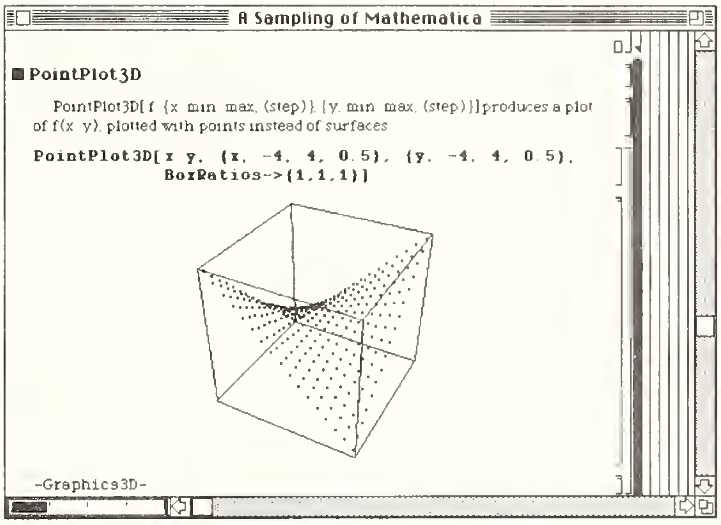
During his keynote address, John Scully had a lot to say about the Macintosh LC (left), which has only recently been made available.

Macintosh on Campus

Networks

Kim Arkledge, Director of Administrative Computing at Texas A&M University, talked about the problems and pitfalls of connecting a network of 13,000 Macintosh computers to several huge administrative mainframes. For balance, Dorothy Mulligan, Director of Academic Computing for the Jersey City State College, talked about her experience with 600 Macintosh computers on a small campus network. Both sites have experimented with various tools to simplify administration, and both sites also feel the network administrator plays an important role in introducing people to new ways of doing things, made possible by the network.

A speaker from Tandem Computer gave a session on his company's implementation of an Executive Information System (EIS). Tandem has an internal network that resembles the size of our campus network. Their EIS is similar to what we would call a Campus Wide Information System in the academic environment, for example, an online card cataloguing system or a computerized course registration system. The EIS system Tandem developed in-house is based on HyperCard, and offers a wide range of information. There is a Human Resources database of all employees, complete with photographs, electronic mail addresses, and phone numbers. There are also maps indicating office locations, and scheduling tools which allow users to coordinate the booking of co-workers for meetings. This application was a well thought out, well designed and aesthetically pleasing HyperCard program.



A Sampling of Mathematica

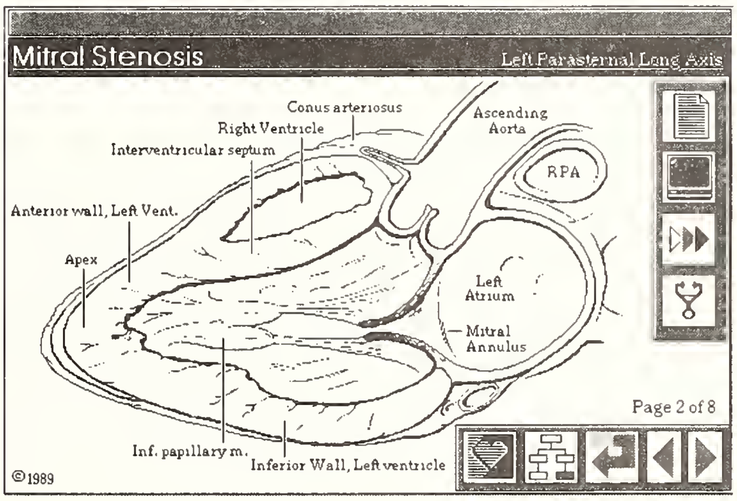
PointPlot3D

PointPlot3D[f {x min max, (step)}, {y, min max, (step)}] produces a plot of f(x y), plotted with points instead of surfaces

```
PointPlot3D[x y. {x. -4. 4, 0.5}, {y. -4. 4, 0.5},
          BoxRatios->{1,1,1}]
```

-Graphics3D-

Sample Mathematica notebook. The lines on the right-hand side of the screen represent underlying pages.



Sample screen from the "Cardiac Imaging" HyperCard stack.

In the Classroom

A very interesting presentation was given by Apple Computer's Curriculum Solutions Group on the use of the Macintosh computer in the classroom. The session was entitled "The Highly Educated Mac" and it was divided into three areas: mathematics, medicine, and English literature. The basic premise of the session was to show how the technology can be used to empower faculty and students with the ability to perform very different "what if..." types of analysis. The "what if..." question would not be limited to strictly mathematical or computational models, but could also be applied to other disciplines through the use of creative, content-rich, and technologically advanced courseware.

The classic example was the use of the Mathematica program to teach introductory calculus. Mathematica allows students to quickly compute, evaluate, simplify, and graph complex equations. An instructor can create "notebooks" that are the electronic equivalents of a standard course textbook. In a standard textbook, the example questions at the end of the chapter are static. Using Mathematica, however, a student can answer "what if" questions by rearranging the provided examples. Unlike a textbook, Mathematica will recompute and re-graph the result, permitting the student to go beyond the provided material.

In medicine, the "what if…" may take a different form. Dr. C. Carl Jaffe, Dr. Patrick J. Lynch, and Dr. Arnold Smeulders at the Yale School of Medicine use Macintosh computers and laser discs to teach interns about cardiac imaging. The application uses HyperCard to show line drawings of the heart. The intern can click on various parts of the heart and zoom in for more detail. The line art drawing can also be animated to show how the heart functions. To correlate this to diagnostic procedures, interns ask the Macintosh to show them an animated electrocardiogram. The Macintosh also produces the sounds the doctor should hear during examination. A full motion ultrasound can also be viewed. At any time the intern can ask "what if" questions. For example, if the patient is suffering from mitral stenosis, the doctor can see an animation showing that valves are not closing properly, resulting in blood flow back into the ventricle in severe cases. The intern can compare a severe case, a mild case, and a normal heart instantly. For each, he can see and hear what the ultrasound, heartbeat, and electrocardiogram would be like.

The final example of the "what if…" analysis was The Stanford Shakespeare Project. This exploration of Hamlet was built with HyperCard and a laser disc. Students can view and compare two interpretations of this famous play, a British work directed by Richardson and a Russian work by Kozynstev. They can quickly see the same scene performed in the British or Russian version. The results of this kind of "what if…" are truly amazing. To provide more alternatives for exploration Professor Friedlander, the project's creator, cleverly used the stereo sound track available on the laser disc. Instead of stereo sound, he uses one track for the original text and the other track for the interior monologue. Students can view a scene from Hamlet while alternating between regular Shakespearean dialogue and "natural English" comments on the character's thoughts and emotions. This kind of "what if..." is more difficult to accomplish with traditional teaching methods.

Multimedia: Desktop Video, etc.

MacroMind, a leading multimedia company, announced and showed a simple video editing, composition, and printing system called **MediaMaker.** Using MediaMaker, you can combine camcorder-produced video, sound, animations created with packages like MacroMind Director, graphs, and scanned images. Using what looks like a slide sorting table, this "multimedia desktop" allows you to move icons representing the pieces of your final presentation, assembling them onto a time line. The system is a Macintosh application that works in concert with third party hardware peripherals and allows you to control a number of multimedia devices such as laser discs, CD ROM players, video tape recorders, as well as animation sequences created on the Macintosh. Once the assembly and timing process is complete, you can print the presentation to a Video Tape Recorder. The finished tape can be viewed using a consumer-grade VHS tape player, without the need for other, often extremely expensive, hardware.

Networks

Cabling

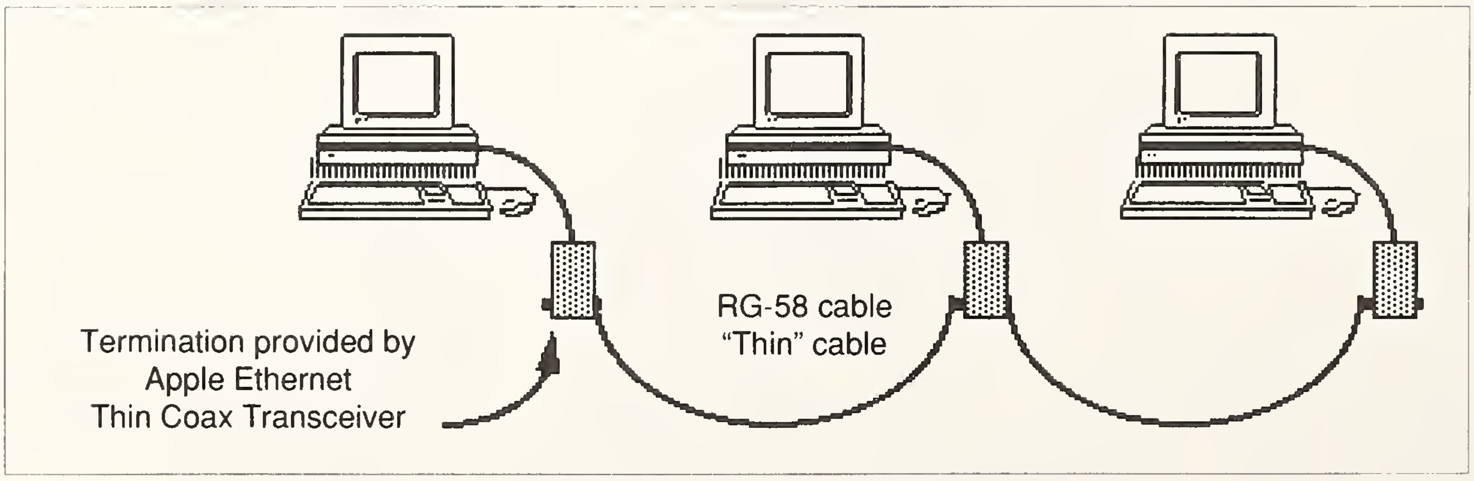
During the show Apple introduced a new way to wire Macintosh computers. The new "plug-and-play" Apple Ethernet is much faster than LocalTalk wiring, while preserving the identical easy look and feel networking Macintosh users are used to. Of course, other vendors have had Ethernet hardware for Macintosh computers for some time. Apple's new network cards and transceivers are fully compatible, and even simplify the wiring process through such things as self-terminating connectors. The goal is to make it as easy to wire as LocalTalk/ Phonenet. All Macintosh com-puters support this new wiring scheme, either with Apple or third party products. Most small locations without on-staff networking experts should directly benefit from these solutions. As well, Apple's endorsement of the Ethernet standard signifies their future networking direction.

Application on the Network

UTCS supports CE Software's QuickMail, an electronic mail package for the Macintosh computer. The last show I attended yielded contacts with other QuickMail users at large American and European universities. I also had a chance to talk to QuickMail developers. This year none of the members of the QuickMail development team were present. They were all very busy preparing a new version of the program, QuickMail 3.0, an upgrade to our current version 2.3.2. The upcoming Beta version will be of great interest to us, since it includes many of the new features for which people have been asking. (Beta versions are partially completed programs that software companies test with some of their larger and more favoured customers, before finalizing all features and releasing the program.

Since QuickMail had nothing to show, I surveyed the competition. Microsoft was showing the new version of their Macintosh electronic mail package, **Microsoft Mail** version 3.0. Their new version includes many new and interesting features, among them gateways for the Internet, the university research network. After spending some time talking to Microsoft, and making a few contacts, I asked many questions about Microsoft's direction regarding Macintosh-IBM PC electronic mail strategy. Many departments on our campus have a mix of Macintoshes and PCs, and

Apple Thin Coaxial Ethernet cables.



have expressed interest in supporting both types. Microsoft has plans to create a uniform interface to most of their products, including their electronic mail solutions for the Macintosh and for Microsoft Windows. Unofficially, Microsoft confirmed that it has purchased a leading IBM PC electronic mail package, **NetWork Courier,** to further this aim.

The only other e-mail package for the Macintosh worth any mention was **cc:mail.** Although cc:mail is relatively unknown in the Macintosh market, it is very well established on the PC side of things. The Macintosh version of the cc:mail program shows that the company is committed to supporting both computing platforms. The cc:mail package uses the Novell file server as the electronic mail post office. The most suitable installations for cc:mail network are predominantly PC-based, with both PCs and Macintoshes connected to the Novell server. The Macintosh version of cc:mail also shows that the company is beginning to understand the graphical user interface issues, although the current PC version has a confusing character-based interface. A Windows version of the package is expected soon.

Honourable Mention–EXCEL 3.0

The day before the show, Microsoft held a press conference to announce new versions of Excel for the Macintosh and for Windows. The new Excel version 3.0 is currently only available for the IBM PC. To run it, you need to buy Microsoft Windows separately. A Macintosh version is expected in the first half of 1991. A major new feature of Excel is what Microsoft calls Object Linking and Embedding (OLB). OLB allows you to update items you have cut and pasted into your spreadsheet automatically. Other major new features include:

- three-dimensional charting capability
- a Toolbar icon which allows you to select actions without using a pulldown menu
- eight level horizontal and vertical outlining, allowing collapse of a table to essential information
- ability to consolidate up to 256 worksheets
- ability to recalculate 100 times faster than before
- a one-variable equation solver with optional third-party multiple-variable solver
- ability to mix text and graphics

Worksheets can now display up to sixteen custom colours. This limit, imposed by the current IBM VGA standard, will apply also to Macintosh computers that can display more colours, in the name of compatibility. In fact, Microsoft is emphasizing improved Macintosh and IBM PC document compatibility. This should be of interest to groups who work in mixed environments and need to exchange data frequently.

For more information about any items mentioned in this article, or any other interesting programs that I may have seen, please call Dariusz Dabek at 978-6878 or send e-mail to *dabek@utcs.utoronto.ca*

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Maureen Monné
monne@vm.utcs.utoronto.ca

Microcomputer Short Courses

Irene Rosiecki
rosiecki@vm.utcs.utoronto.ca

UTCS offers various noncredit microcomputer courses to faculty, staff, and graduate students of the University of Toronto. These courses cover a number of software programs available for the PC or the Macintosh. Whether you will be typing a thesis on a word processor, or working with spreadsheets, databases, or desktop publishing, we may be able to help you get started.

Our class sizes are small to allow for much individual attention. Continuing support is available upon completion of a course.

The following is a list of the microcomputer courses taught at UTCS:

- Introduction to dBASE IV
- Introduction to Disk Operating System (DOS)
- Electronic Mail Seminar
- Excel on the Macintosh
- Introduction to FoxBASE+/Mac 2.0
- Introduction to HyperCard
- Introduction to Lotus 1-2-3
- Introduction to PageMaker
- ProComm Communications Seminar
- Introduction to SAS on the PC
- Intermediate SAS – Data Processing
- Intermediate SAS – Statistics
- SAS/Graph Seminar
- Microsoft Word on the Macintosh
- Microsoft Word on the PC
- Introduction to WordPerfect 5.1
- Advanced WordPerfect 5.1 Topics

To find out about course dates and registration procedures, or to book a place in any of these courses, please contact Irene Rosiecki at 978-4565. Courses are filled on a first-come, first-served basis. The more popular courses fill up quickly, but waiting lists are maintained in case of cancellations.

How to Analyze Repeated Measures Designs Using SPSS

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This is my third article on how to analyze repeated measures designs. I will be focussing on how to use SPSS/PC+ (version 3.1) and SPSS-X (version 3.0) to do these type of analyses.

The first article on the analysis of repeated measures designs appeared in *ComputerNews,* November/December 1990 (page 27), and discussed how to analyze these designs using SAS. Please read that article before continuing to read this article because important terminology such as *data presentation method* and *data analysis method* are defined and discussed at length. For this article, I will assume you have read the first article, and that you are familiar with analysis of variance techniques and terminology. I will also assume that you know how build and submit an SPSS program which creates an SPSS system file and executes SPSS procedure commands and subcommands. The example data sets I will be using in this article are the same data sets that I used in the first article.

The second article in this series discussed how to use SYSTAT 5.0 for the Macintosh computer for these type of analyses. This article appeared in *ComputerNews,* January/February 1991 (page 13). It is not required reading for understanding the topics discussed below.

SPSS's MANOVA procedure is used for the analysis of repeated measures designs. The subcommands that will be discussed in this article are WSFACTORS, DESIGN, RENAME, PRINT, CONTRAST, and OMEANS. For more details, please see the following two manuals: *SPSS/PC+ Advanced Statistics V2.0* (1988) and *SPSS-X User's Guide* (1988). All figures appearing in this article have been generated from SPSS/PC+ programs and listing files. I have tested these programs on SPSS-X under CMS, and although there are slight changes in the command syntax (for example, periods (.) are not required), there are no major differences in the output generated. I will use the acronym SPSS to refer to both SPSS/PC+ and SPSS-X.

The first example of a repeated measures design is taken from Keppel, 1982, Section 17.3. This design has one within-subject factor (treatment) where each of the six subjects has been given all three treatments. When the data are read into an SPSS system file in the multivariate presentation method, there are four variables, subject number and the results from each of the treatments, and six cases (see *Figure 1*). The corresponding SPSS code to analyze these data is listed in *Figure 2.*

Figure 1

SUBJECT	T1	T2	T3
1	13	24	22
2	6	30	29
3	25	13	23
4	20	16	25
5	25	37	16
6	19	30	12

Figure 2

```
MANOVA t1 t2 t3
 /WSFACTORS trtmt (3)
 /RENAME = mntrtmt devt1 devt2
 /PRINT CELLINFO (MEANS) SIGNIF (MULTIV AVERF) TRANSFORM.
```

The MANOVA command is followed by the dependent variables T1, T2, and T3, which represent the levels of the within-subject factor. Since there are no between-subject factors, the keyword BY is not required. The WSFACTORS subcommand names the within-subject factor TRTMT and identifies that it has three levels. This subcommand is required and must follow the MANOVA specification. For computational reasons, SPSS automatically transforms the variables representing the within-subject factor TRTMT into new variables which are linear combinations of the original variables. By default, the names of the transformed variables are T1, T2, and T3. In order to avoid confusing the original variables with the transformed variables, I have used the RENAME subcommand to change the names of the transformed variables. For repeated measures analysis, the default transformation is an orthonormalized version of the deviation transformation. The transformation matrix may be printed by adding the keyword TRANSFORM on the PRINT subcommand (see *Figure 3*).

When no WSDESIGN or DESIGN statements are submitted, a full factorial model is generated (for within-subject and between-subject factors where appropriate). SPSS automatically produces both the univariate and the multivariate analytical results (see *Figure 4*) when analyzing repeated measures data. The SIGNIF keyword with the MULTIV (multivariate) and AVERF (averaged F-tests) options on the PRINT subcommand is not really necessary since it is default output. SPSS will display the means for each of the levels of the repeated factor when CELLINFO(MEANS) is added to the PRINT subcommand. The univariate test of the hypothesis that the mean levels of T1, T2, and T3 are equal is found in the section of the output labelled "AVERAGED Tests of Significance" and is based on the analysis of the transformed variables DEVT1 and DEVT2. The error term is the interaction of

Figure 3

```
Orthonormalized Transformation Matrix (Transposed)

          MNTRTMT     DEVT1     DEVT2

T1         .577        .707     -.408
T2         .577        .000      .816
T3         .577       -.707     -.408
```

Figure 4

```
Order of Variables for Analysis

  Variates     Covariates

  DEVT1
  DEVT2

   2 Dependent Variables
   0 Covariates

- - - - - - - - - -
Note.. TRANSFORMED variables are in the variates column.
       These TRANSFORMED variables correspond to the
       'TRTMT' WITHIN-SUBJECT effect.

- - - - - - - - - -

Tests involving 'TRTMT' Within-Subject Effect.

 Mauchly sphericity test, W =      .98641
 Chi-square approx. =              .05474 with 2 D. F.
 Significance =                    .973

 Greenhouse-Geisser Epsilon =      .98659
 Huynh-Feldt Epsilon =            1.00000
 Lower-bound Epsilon =             .50000

- - - - - - - - - -
EFFECT .. TRTMT
 Multivariate Tests of Significance (S = 1, M = 0, N = 1 )

 Test Name    Value   Approx. F   Hypoth. DF   Error DF   Sig. of F

 Pillais     .26261    .71226       2.00        4.00        .544
 Hotelling   .35613    .71226       2.00        4.00        .544
 Wilks       .73739    .71226       2.00        4.00        .544
 Roys        .26261

- - - - - - - - - -
Tests involving 'TRTMT' Within-Subject Effect.

 AVERAGED Tests of Significance for T using UNIQUE sums of squares
 Source of Variation      SS        DF       MS      F    Sig of F

 WITHIN CELLS           799.89      10     79.99
 TRTMT                  147.44       2     73.72    .92     .429
```

subject and the levels of the treatments. Here, the hypothesis is not rejected since the p-value is 0.429. See Keppel, 1982, page 389 for the ANOVA table for this example.

SPSS gives the results of several multivariate tests, including Wilk's Lambda and Pillai's Trace, which test the hypothesis that the mean levels of T1, T2, and T3 are equal. See the section in the output labelled "Multivariate Tests of Significance".

Remember that for the univariate F-test for the repeated factor to be valid, there is the assumption that there is equality of variances and equality of covariances amongst the levels of the repeated factor. SPSS automatically performs the Mauchly sphericity test in order to test the validity of this assumption and prints the epsilon values for the Greenhouse-Geisser and Huynh-Feldt corrections to the univariate F-tests. As an analyst, you have to be careful in interpreting the analytical results, especially if the univariate and multivariate test results differ. See Cole and Grizzle, 1966, Huynh and Feldt, 1970, and Looney and Stanley, 1989 for further discussions about this topic.

If the data for the previous example were entered in the univariate presentation method (see *Figure 5*), you would have three cases per subject. The variable named TRTMT identifies which treatment result is recorded in the next variable labelled RESULT. The univariate test results displayed in *Figure 4* could be reproduced with this new data set using the commands listed in *Figure 6*. The MANOVA command now lists one dependent variable, RESULT, and two factors, TRTMT and SUBJECT. The DESIGN subcommand describes the model to be analyzed. SUBJECT, TRTMT, and SUBJECT by TRTMT are terms in the model and the TRTMT F-test will based on the TRTMT mean square versus the SUBJECT by TRTMT mean square. A fully saturated model has been defined in this DESIGN subcommand and SPSS warns you that there are too few degrees of freedom for the residual error term. The test results are presented in *Figure 7*.

Remember, if you choose the second method of analyzing your repeated measure data, you need to define the complete model and perform the correct F-tests yourself. You will not be able to obtain the multivariate test results nor perform the Mauchly sphericity test.

The second example is taken from Winer, 1971, page 546. This design has six subjects divided into two groups, which is recorded by the between-group factor A. The two within-subject factors, B and C, have three levels each, so subjects are measured nine times. See *Figure 8* for the multivariate data presentation

Figure 5

SUBJECT	TRTMT	RESULT
1	1	13
1	2	24
1	3	22
2	1	6
2	2	30
2	3	29
3	1	25
3	2	13
3	3	23
4	1	20
4	2	16
4	3	25
5	1	25
5	2	37
5	3	16
6	1	19
6	2	30
6	3	12

Figure 6

```
MANOVA result BY trtmt (1,3) subject (1,6)
 /DESIGN=subject, trtmt vs 1,
      subject by trtmt=1.
```

Figure 7

```
Tests of Significance for RESULT using UNIQUE sums of squares
Source of Variation      SS     DF      MS       F   Sig of F

RESIDUAL                .00     0        .
CONSTANT            8234.72     1   8234.72      .      .
SUBJECT               82.94     5     16.59      .      .

Tests of Significance for RESULT using UNIQUE sums of squares
Source of Variation      SS     DF      MS       F   Sig of F

Error 1              799.89    10     79.99
TRTMT                147.44     2     73.72     .92    .429
```

Figure 8

SUBJECT	A	B1C1	B1C2	B1C3	B2C1	B2C2	B2C3	B3C1	B3C2	B3C3
1	1	45	53	60	40	52	57	28	37	46
2	1	35	41	50	30	37	47	25	32	41
3	1	60	65	75	58	54	70	40	47	50
4	2	50	48	61	25	34	51	16	23	35
5	2	42	45	55	30	37	43	22	27	37
6	2	56	60	77	40	39	57	31	29	46

of the data. Notice that the variable names for the repeated measures reflect the level of within-subject factors. For example, B1C3 is the measurement for B, level 1, and C, level 3. *Figure 9* displays the SPSS commands needed to analyze this design. Notice that the dependent variables are listed in such a way that the level of C changes before the level of B. The MANOVA statement lists the nine repeated measures representing the two within-subject factors followed by the between-group factor A. The WSFACTORS subcommand names the within-subject factors B and C.

I have selected a portion of the analytical results to be displayed in *Figure 10*. SPSS automatically produces results for the multivariate and univariate analytical methods. Since the multivariate and univariate results for the between-group factor A are the same, they can be found in the section of the output labelled "Tests of Between-Subject Effects." Here the hypothesis that there are no group differences is not rejected since the p-value is 0.435. The test results for the within-subject factors are in sections labelled "AVERAGED Tests of Significance." I have included the univariate tests results for the hypothesis that there are no differences in the means for the levels of B (rejected with p-value of 0.000) and for the hypothesis that there is no A*B interaction effect (rejected with p-value of 0.029). You should compare the results of these tests with the corresponding multivariate tests before completing your analysis.

The sums of squares for the hypothesis that there are no differences in the means for the levels of B can be partitioned into orthogonal components representing the polynomial contrasts which, in this case, are the linear component (degree 1) and the quadratic component (degree 2). In the MANOVA procedure, the CONTRAST subcommand is needed to list the within-subject factor B along with the request for the POLYNOMIAL transformation. The SIGNIF(UNIV) needs to be added to the PRINT subcommand so that the appropriate univariate F-tests are performed. These F-tests are summarized in sections of the output labelled "Univariate F-tests." See *Figure 11* for example output. The univariate tests for T2 show that there is no linear trend in the mean levels of B for each level of A (p-value of 0.103) and that there is evidence of a trend across all levels of A (p-value of 0.001). The T3 univariate tests are tests for quadratic trends.

The complete ANOVA table for this example can be found in Winer,

Figure 9

```
MANOVA b1c1 b1c2 b1c3 b2c1 b2c2 b2c3 b3c1 b3c2 b3c3 BY a (1,2)
 /WSFACTORS b (3) c (3)
 /PRINT SIGNIF (MULTIV AVERF UNIV) TRANSFORM
 /CONSTRAST (b) POLYNOMIAL.
```

Figure 10

```
Tests of Between-Subjects Effects.

 Tests of Significance for T1 using UNIQUE sums of squares
 Source of Variation      SS      DF        MS          F     Sig of F

 WITHIN CELLS          2491.11     4      622.78
 CONSTANT            105868.17     1   105868.17   169.99      .000
 A                      468.17     1      468.17      .75      .435

-----------------------------------------------------------------
Tests involving 'B' Within-Subject Effect.

 AVERAGED Tests of Significance for MEAS.1 using UNIQUE sums of squares
 Source of Variation      SS      DF        MS          F     Sig of F

 WITHIN CELLS           234.89     8       29.36
 B                     3722.33     2     1861.17    63.39      .000
 A BY B                 333.00     2      166.50     5.67      .029
```

Figure 11

```
Tests involving 'B' Within-Subject Effect.

 EFFECT .. A BY B
 Univariate F-tests with (1,4) D. F.

 Variable    Hypoth. SS    Error SS    Hypoth. MS    Error MS         F      Sig. of F

 T2           225.00000   202.66667    225.00000     50.66667    4.44079      .103
 T3           108.00000    32.22222    108.00000      8.05556   13.40690      .022

  EFFECT .. B
  Univariate F-tests with (1,4) D. F.

 Variable    Hypoth. SS    Error SS    Hypoth. MS    Error MS         F      Sig. of F

 T2          3721.00000   202.66667   3721.00000     50.66667   73.44079      .001
 T3             1.33333    32.22222      1.33333      8.05556     .16552      .705
```

1971, page 549. It may be helpful for you to see the ANOVA table before examining all the output generated by SPSS. SPSS, like other software packages, does not produce a nice summary of the univariate results when there are two within-subject factors.

Figure 12 displays a portion of the data from the previous example in the univariate data presentation method. If you wish to produce the univariate analytical results when your data is entered in this manner, you need to understand clearly the model you are fitting to your data. *Figure 13* contains the SPSS commands to generate all the F-tests required for the previous example. Note that all the F-ratios have SUBJECT within A (or a corresponding interaction term) as the denominator. Also, the METHOD subcommand is needed in order to request SSTYPE SEQUENTIAL, a hierarchical decomposition of the sums of squares. When the multivariate data presentation method is used, the analysis is performed on transformed variables and the default SSTYPE UNIQUE is valid.

The only advantage to using the univariate analysis method for this complicated design is the ability to use subcommands such as OMEANS for the within-subject factors.

I have not covered all the MANOVA subcommands and options which apply to repeated measures designs in this article. For example, SPSS can handle doubly multivariate designs in which subjects are measured on two or more responses on two or more occasions.

Using SPSS/PC+ to analyze repeated measures data is aided by the use of the menu and help system. The menus help identify which commands and subcommands are available and which ones are required. I would recommend, though, that you read through the manuals mentioned earlier to become more familiar with the SPSS commands. There are no major differences between SPSS-X and SPSS/PC+ for these analyses other than there is always the possibility of memory problems if you have a complicated repeated measures design and you are using SPSS/PC+.

I hope this article has helped you to understand how to analyze repeated measures data using SPSS. I have included a list of references which discuss this topic in further detail. If you have any questions, please call me at 978-5128 or send an e-mail message to *sgardner@vm.utcs.utoronto.ca*

References:

Cole, J.W.L. and Grizzle, J. E. "Applications of Multivariate Analysis of Variance to Repeated Measurements Experiments" *Biometrics,* vol. 22, (1966), 810-828.

Huynh, H. and Feldt, L.S. "Conditions Under Which Mean Square Ratios in Repeated Measures Design Have Exact F-Distributions" *Journal of the American Statistical Association,* vol. 65, (1970), 1582-1589.

Keppel, G. *Design and Analysis, A Researcher's Handbook* (2nd Ed.). Prentice-Hall, Inc., 1982.

Looney, S.W. and Stanley, W.B. "Exploratory Repeated Measures Analysis for Two or More Groups" *The American Statistician,* vol. 43, No. 4 (1989), 220-225.

Winer, B.J. *Statistical Principles in Experimental Design* (2nd Ed.). New York: McGraw-Hill, 1962.

Figure 12

```
SUBJECT   A   B   C   RESULT

   1      1   1   1     45
   1      1   1   2     53
   1      1   1   3     60
   1      1   2   1     40
   1      1   2   2     52
   1      1   2   3     57
   1      1   3   1     28
   1      1   3   2     37
   1      1   3   3     46
   2      1   1   1     35
   2      1   1   2     41
   2      1   1   3     50
   2      1   2   1     30
                              ...
```

Figure 13

```
MANOVA result BY a (1,2) b (1,3) c (1,3) subject (1,6)
 /METHOD SSTYPE SEQUENTIAL
 /DESIGN=a vs 1, subject w a=1,
        b vs 2, a by b vs 2, b by subject w a=2,
        c vs 3, a by c vs 3, c by subject w a=3,
        b by c vs 4, a by b by c vs 4, b by c by subject w a=4.
```

Comparison of Figures from Part One and Part Three

Part 1: Nov/Dec	Part 3: March
Table 1	Figure 1
Figure 1	Figure 2
	Figure 3
Figures 2&3	Figure 4
Table 2	Figure 5
Figure 4	Figure 6
Figure 5	Figure 7
Table 3	Figure 8
Figure 6	Figure 9
Figure 7	Figure 10
Figure 8	Figure 11
Table 4	Figure 12
Figure 9	Figure 13
Figure 8	
Table 4	
Figure 9	

Theorist :

Symbolic Manipulation Software for the Macintosh

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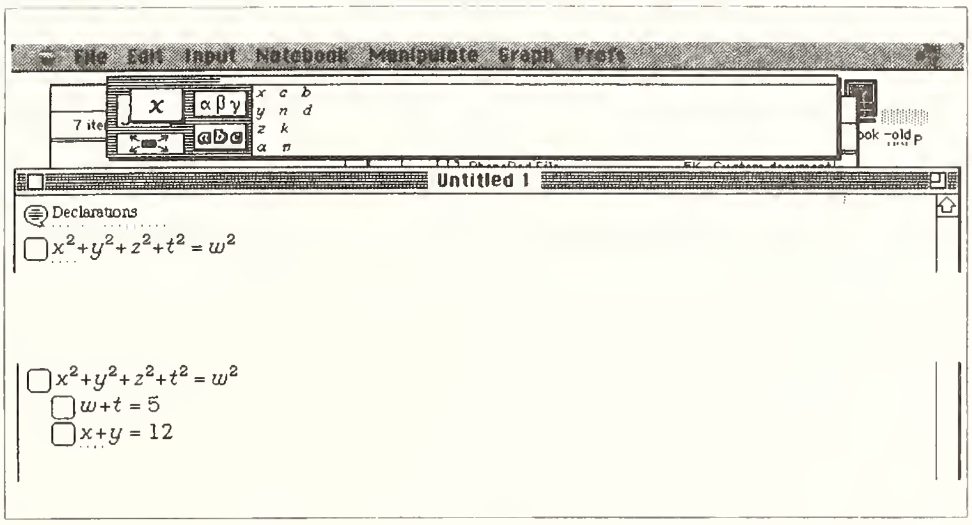
Theorist is the newest entry into the field of symbolic manipulation software. It makes very good use of the features of the Macintosh system, creating a user-friendly package with a very good interface. Mathematical expressions appear in their natural form; manipulations such as rearrangements of various terms can be accomplished very easily with the help of the mouse. This ease of use also applies to picking out just a few terms from a large expression, and performing manipulations on the selected terms only. Such tasks are relatively awkward in other symbolic manipulation packages. On the other hand, in comparison with established packages like MACSYMA, REDUCE, Maple, Mathematica, or even Derive, the range of mathematical knowledge which Theorist possesses is very limited, although the program provides an easy method for increasing its "expertise." This is discussed further in the review.

Another strength of Theorist is its ability to render graphics, in particular three-dimensional (3D) graphics. Theorist also has an option for creating animations in a simple way.

When you start up Theorist, the screen looks like the one shown in the upper part of *Figure 1.* (On startup, you see only a question mark following the square icon; I entered the equation you see in the figure. The dots under the equation have a special meaning, which is explained later.) At the top you see the main menu, then a palette you use to enter mathematical expressions, and below that the notebook, or work area. In the notebook, labelled "Untitled 1," you can see two Theorist propositions. The first one, Declarations, is a comment. As explained later, it contains hidden declarations. Anything you enter there (on the line with the balloon) is ignored by Theorist. The second proposition is an assumption, an equation that you type to tell Theorist something. Different types of propositions have different icons associated with them, as you see here and below. Three more proposition types and corresponding icons are illustrated in *Figure 2.* Mathematical formulae can be entered into an assumption either by using the keyboard or by clicking on the palette with the mouse. A second palette, shown in *Figure 2,* is used to enter operators (you can switch between the two palettes by clicking on the overlapping *x* and *f(x)* icons on the left side). Certain mathematical structures can also be entered using the Input menu item. Input offers the following commands: Division, Square Root, Index (for entering subscripts), Power, Summation, Row Number, Column Number (these two are used to enter matrices), and three other commands not discussed here.

Notebooks are organized in a hierarchical manner. Propositions can have "daughters;" these "daughters" can have their own "daughters," and so on (parallel propositions are referred to as "sisters"). The lower part of *Figure 1* shows that the proposition from the upper part has two daughters. The daughters are indented. Daughters of a given proposition can be hidden (collapsed) by using the Collapse command from the Notebook menu. If a proposition has "collapsed" daughters, you will see several dots underneath it. The number of dots, minus three, corresponds to number of daughters. Thus, six dots equals three daughters. When the propositions from the lower part of *Figure 1* are collapsed, only the top proposition shows, as demonstrated in the upper part of the figure (note the dots and the grey area behind). The last proposition in the lower part of *Figure 1* has four dots underneath, which means that it has one daughter of its own, collapsed. This ability to hide some information and leave only the top-most proposition visible can be very useful when you are organizing your notebooks (this is reminiscent of the notebooks from Mathematica, a Macintosh program).



Declarations

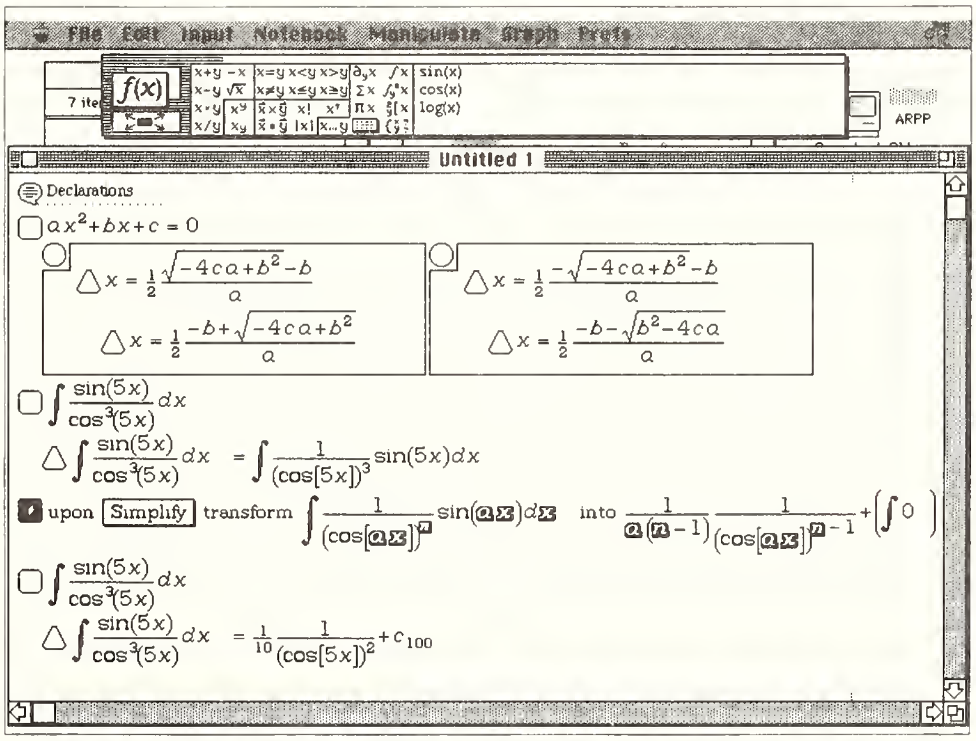
☐ $x^2+y^2+z^2+t^2=w^2$

☐ $x^2+y^2+z^2+t^2=w^2$

☐ $w+t=5$

☐ $x+y=12$

Figure 1: Theorist screen showing the main menu, the symbols palette, comment, and assumption propositions. Note six dots under the assumption, indicating that it has three daughter propositions collapsed. In the bottom part of the figure the assumption is expanded, showing two daughter propositions. The four dots under the last proposition show that it has one daughter proposition of its own. The comment proposition also has dots under it, indicating collapsed (hidden) declarations.



Declarations

☐ $ax^2+bx+c=0$

○ $\triangle\ x=\frac{1}{2}\frac{\sqrt{-4ca+b^2}-b}{a}$

$\triangle\ x=\frac{1}{2}\frac{-b+\sqrt{-4ca+b^2}}{a}$

○ $\triangle\ x=\frac{1}{2}\frac{-\sqrt{-4ca+b^2}-b}{a}$

$\triangle\ x=\frac{1}{2}\frac{-b-\sqrt{b^2-4ca}}{a}$

☐ $\int\frac{\sin(5x)}{\cos^3(5x)}dx$

$\triangle\ \int\frac{\sin(5x)}{\cos^3(5x)}dx=\int\frac{1}{(\cos[5x])^3}\sin(5x)dx$

■ upon Simplify transform $\int\frac{1}{(\cos[ax])^n}\sin(ax)dx$ into $\frac{1}{a(n-1)}\frac{1}{(\cos[ax])^{n-1}}+\left(\int 0\right)$

☐ $\int\frac{\sin(5x)}{\cos^3(5x)}dx$

$\triangle\ \int\frac{\sin(5x)}{\cos^3(5x)}dx=\frac{1}{10}\frac{1}{(\cos[5x])^2}+c_{100}$

Figure 2: Some manipulations performed by Theorist. A definition of Transform Rule and its application for symbolic integration are demonstrated.

The dots under the comment "Declarations" indicate that it also has daughter propositions. These daughter propositions declare a number of default names such as log, sin, and so on. Hence, the comment reads "Declarations."

Manipulating Expressions

Many simple manipulations, such as commuting terms, may be carried out by selecting and dragging terms around, or by using keystrokes. Likewise, you can select one or more equations, or pieces of equations, and choose a command from the Manipulate menu. The Manipulate menu has the following commands: Calculate, Simplify, MiniExpand, Expand, Collect, Factor, Commute, Isolate, Move Over, Transform, Substitute, Apply, Taylor Series, and Int. by Parts.

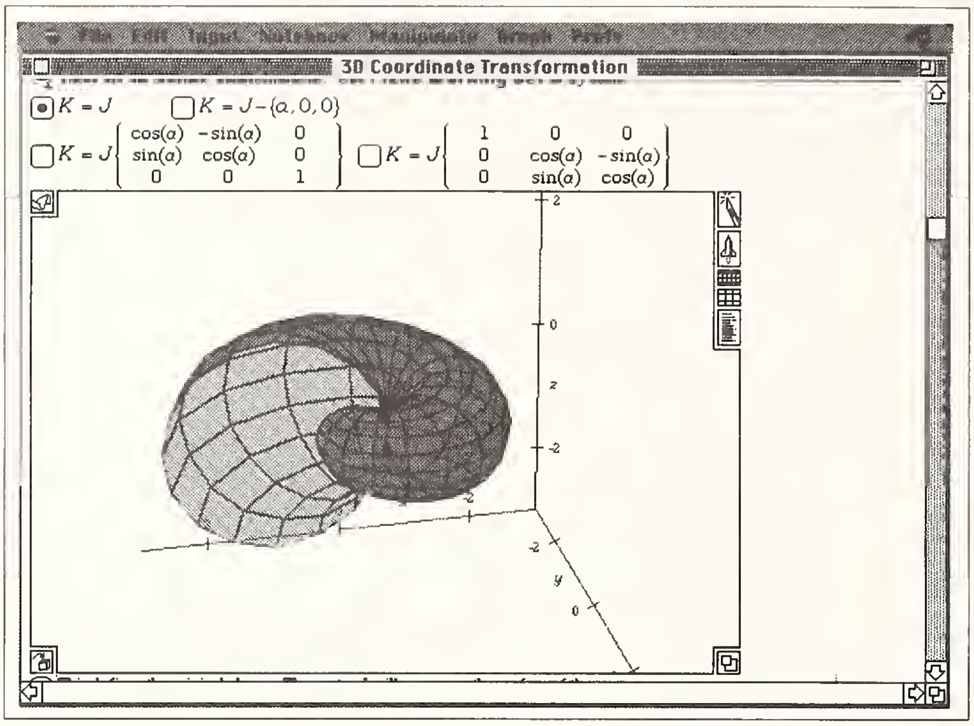
A few examples are shown in *Figure 2*. To solve the quadratic equation, you select x (both occurrences), and then choose Isolate from the Manipulate menu. Results of manipulations, called "Conclusions," are marked with a triangle icon. For the above situation we have two cases, marked with a circle icon. The first solution demonstrates Theorist's ability to rearrange terms at will. This was done by selecting the whole expression in the numerator and then choosing Commute from the Manipulate menu. Alternatively, you could select one of the terms and drag it to the other side of the second one. Manipulations can also be carried out "in place;" that is, with a new form of an expression replacing the old one, instead of creating a new proposition. This is done for the second solution by commuting terms under the square root in place.

Next an attempt to calculate an indefinite integral is illustrated. This is done by clicking on the integral sign and choosing Simplify from the Manipulate menu. As you can see, the only result is a slight rearrangement of the integrand: Theorist does not know how to calculate the integral. To perform a task, Theorist uses pattern matching expressions from an internal database of algebraic or calculus rules. This database is very limited, but can easily be increased, as shown in the following line in *Figure 2*. There Theorist is being given a Transform Rule. Highlighted symbols are wildcard variables, which can represent any expression of a given type (e.g., the outlined "n" represents any positive integer) in an expression pattern. After Theorist learns the rule, it can calculate the integral easily. Note that a Transform Rule does not have to be visible in order to operate. It could be made a daughter of a proposition (e.g., of a comment reading "Integration Rules") and then hidden by collapsing the proposition.

The Theorist diskette contains a number of notebooks with mathematical rules which can be used to increase the program's mathematical expertise. The notebooks cover the following areas: Integral Tables (over 300 integration rules), Laplace Transforms (including inverse transforms), Number Theory, Special Functions (Bessel J, Y, K, and I functions), Gamma and related functions, Orthogonal Polynomials (P, T, H, and L), Spherical Bessel Functions, Zeta Function, and Transcendental Functions. There is also a notebook with vector calculus rules, coordinate conversions and selected infinite series; and another notebook called Standard Rules & Declarations, which contains a selection of the most frequently required rules from the other notebooks.

Graphics

Theorist has very good two-dimensional (2D) and 3D graphics. I shall discuss some of its capabilities using the example of the 3D graph shown in *Figure 3*. There are several buttons available, which are used to manipulate the graph in various ways. In the top right corner you see the knife button. Clicking on it turns the cursor into a knife, enabling you to slice out a piece of graph for closer inspection. Below it you can see the rocketship button, which allows you to zoom a graph in and out. The next two buttons in the series control the number of points used to render the graph; the first one increases the number of points, the second one decreases them. The last button in this group is the details button. When you click on it, details of the graph are exposed at the bottom so that you can see them and edit them by hand. These details include graph bounds, aspect ratio, the distance from which you observe a 3D object, scaling of axes, linestyle (2D), and optical properties of a 3D surface (transparent, translucent, opaque or illuminated, colour settings, and so on). At the bottom right corner of the graph area is a size box , which is used to change the size of the graph viewport. The object in the top left corner is the proposition icon, and the one in the bottom left corner is the orientation icon. The orientation icon, which is present only for 3D graphs, gives you a view of what side of the graph bounding box you are looking at. If you place the cursor inside the graph viewport, the cursor changes into a little hand; when you press the mouse button, an outline of the graph bounding box appears. Moving the cursor around with the mouse button pressed will rotate the box. After you release the button, the graph is redrawn with the new rotation. The orientation icon is correspondingly updated. Clicking on the orientation icon will "home" the graph to the default rotation. In the case of 2D graphs, moving the cursor inside the graph with the mouse button pressed will scroll the graph.


File Edit Input Notebook Manipulate Graph Prefs
3D Coordinate Transformation
2
0
z
-2
-2
y
0

● $K = J$ ☐ $K = J - \{a, 0, 0\}$

☐ $K = J\begin{Bmatrix} \cos(a) & -\sin(a) & 0 \\ \sin(a) & \cos(a) & 0 \\ 0 & 0 & 1 \end{Bmatrix}$ ☐ $K = J\begin{Bmatrix} 1 & 0 & 0 \\ 0 & \cos(a) & -\sin(a) \\ 0 & \sin(a) & \cos(a) \end{Bmatrix}$

Figure 3: An example of the 3D graphics capabilities of Theorist.

If you have several different definitions of a quantity, the one which Theorist uses by default (called the "working definition") is indicated by a dot in the proposition icon. You can see it in *Figure 3,* where the quantity K, which is being plotted, is defined in terms of J (J is defined off the screen). If you change the working definition (by selecting another proposition and choosing the Make Working Def command from the Notebook menu), the selected proposition will acquire the dot in the proposition icon, and the graph will be redrawn to reflect the new definition of K.

Graphs can be animated very easily by using the Animate command from the Graph menu. For instance, if you choose another definition of K in *Figure 3,* you could use animation to see how the graph changes as a function of parameter a.

Theorist allows you to save both black-and-white and colour graphs in PostScript and PICT file format.

You can save the Theorist notebooks that you create during your work session, so that you can continue your work later. You can also print these files on a printer, together with any included graphs.

It is worth mentioning that Prescience also offers a mathematical expressions editor and desk accessory called **Expressionist.** Expressionist enables you to create typeset-quality equations in your word-processing, page layout, and presentation documents. It also allows you to import Theorist files.

In conclusion, Theorist is a well-designed, very friendly package for symbolic manipulations, with great graphics but a limited mathematical knowledge. Notebooks provided by the vendor extend substantially the program's mathematical know-how. You can expect that the available database of mathematical rules for Theorist will grow through input from the user community.

Vendor:
Prescience Corporation
939 Howard Street
San Francisco, CA 94103
USA
(415) 543-2252

Hardware Requirements:
Version 1 -
Macintosh Plus, SE ,or any Mac with enhanced (128KB) ROM and at least 1MB of RAM (will also run on machines with 68020 processors, but will not take advantage of their capabilities)
Version 2 -
Macintosh II, IIx, IIcx, IIci, or SE/30. System version required depends on the machine: for Plus it is 4.2 or 6.0.2; SE and II , 6.0.2 or later; IIx, IIcx, and SE/30, 6.0.3 or later; IIci and Portable, 6.0.4 or later. Both versions are included when you buy Theorist.
Math coprocessor recommended but not required.

Pricing:
US$229 (Mac's Place)
Phone: 1-800-367-4222 (US and Canada)
Fax: (206) 881-3090

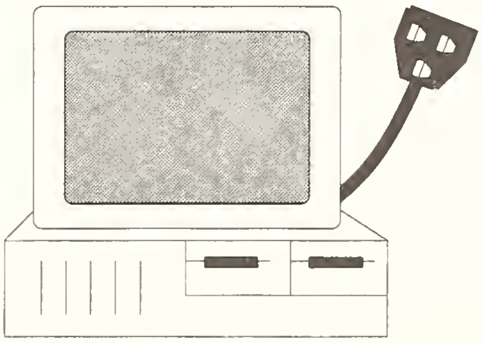
Addendum

After this review was written, we received the following update:

Prescience recently began shipping Theorist 1.1, an upgrade to version 1.0 described in this article. The new version has several enhancements to its algebra, calculus, and graphing capabilities, plus many operations work faster than in previous versions of the program.

The new features include:
- factoring of large polynomials;
- symbolic integration of all rational functions;
- nonlinear root finder solves two equations in two unknowns;
- zero contour plots for graphing implicit equations.

All plugged in with no place to go?



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More Software to Help You with Chaos

Andrzej J. Pindor
apindor@vm.utcs.utoronto.ca

In the past, I have reviewed here in *ComputerNews* several software programs for analyzing systems characterized by chaotic behaviour (i.e., dynamical systems). If you are interested in this subject and would like to read these reviews, please consult the list of references at the end of this article. Below I describe a similar program, **Dynamics**, created by Professor James Yorke of the University of Maryland. Professor Yorke is a leading researcher in the area of chaos. Over the years, he developed the program as a research tool. "Dynamics" is a very powerful program with a lot of options; many of them offer standard diagnostics applied to the dynamical systems; others reflect the directions of research favoured by Professor Yorke.

"Dynamics" offers analysis of the following dynamical systems:

1. *Maps*
- Complex cubic map
- Double rotor map
- Generalized Baker map
- Henon map
- Ikeda/Hammel/Jones/Maloney Laser map
- Pulsed Rotor and standard map
- Tinkerbell map
- Degenerate Double Rotor map
- Quasiperiodicity map
- Random Rotate map
- Zaslavskii Random Rotate map

2. *Differential equations systems*
- Forced double-well Duffing equation
- Lorenz system
- Lorenz's system Poincare Return map
- Forced damped pendulum equation
- parametric Duffing equation
- Hamiltonian system for $H=(p^2 + q^2)/2 + u^2*v^2 = \text{const}$
- N. Samardzija/ L. Geller odd symmetry Lorenz-like system
- Forced Van der Pol equation
- Two forced coupled Van der Pol equations

You can add your own systems to this list, as explained below.

An Overview of Capabilities

"Dynamics" can plot trajectories of the systems. You can store the results interactively; furthermore, you can change initial conditions, parameters, and the scale of the screen. You can split the screen into quadrants if desired. The different quadrant windows can have different coordinates to be plotted, and all windows can be plotted simultaneously if you wish.

Newton's method can be used for finding fixed points and periodic orbits. When the system is two dimensional, the eigenvalues and eigenvectors of the derivatives of the process can be evaluated at periodic orbits. Choosing the initial point for the Newton method is carried out interactively.

Lyapunov exponents and the Lyapunov dimension of an attractor can be calculated. When there are two or more attractors, basins can be computed and displayed.

Orbits can be followed forward and backward. Straddle methods permit the finding and following of orbits that are chaotic but do not lie on a chaotic

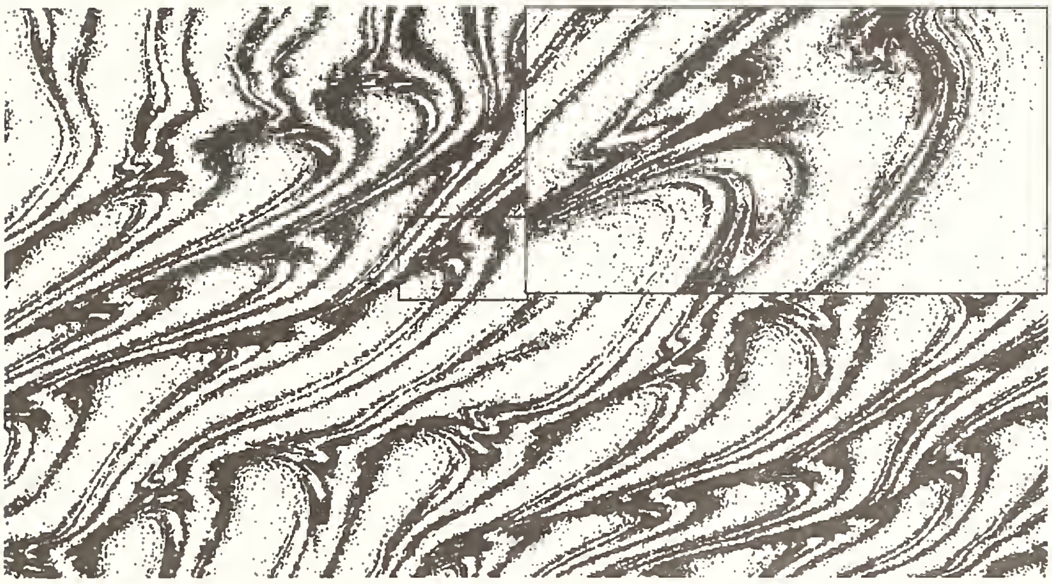

Figure 1: Trajectory of the Quasiperiodicity map. The upper right-hand quadrant shows an enlargement of the small region in the centre.

attractor. Unstable and stable manifolds of periodic orbits can be plotted.

Bifurcation diagrams can be created and displayed.

Images which are created on the screen can be sent directly to an IBM Graphics printer, Epson-compatible printer, or HP printer. You can also save the current picture, together with relevant parameters, in a file. By default, a high-resolution picture is created (960 dots horizontally by 544 vertically). In the process of display, this is reduced to reflect the resolution of the device being used.

Figure 1 shows the trajectory for the Quasiperiodicity map created by the program. The upper right-hand quadrant of the figure shows an enlargement of the small region in the centre. When you run the program on a microcomputer, the picture on the screen is placed over the menu, which appears on the left-hand side of the screen. This is a bit inconvenient, since the menu may obscure the picture somewhat. However, when you send the picture to a printer, it comes out without any interfering text, as you see in *Figure 1*. *Figure 1* was generated from a file created by "Dynamics'" program for an HP printer.

"Dynamics'" source code (written in C) is provided with the program. If you want to examine a dynamical system not contained in the program, you can easily add the necessary code. The manual contains detailed instructions that explain how to do this.

Generally speaking, "Dynamics" is an effective research tool for the analysis of dynamical systems. However, since it is a non-commercial product, no effort has been made to make it "flashy" and user friendly. When you consider that Professor Yorke offers the program for a price which just covers the distribution costs, this should not be considered a drawback.

If you would like to examine the program, call Andrzej Pindor at 978-5045.

Vendor:
Professor James A. Yorke
Institute for Physical Science
and Technology
University of Maryland
College Park, Maryland 20742

Hardware Requirements:
IBM PC, XT, AT, PS/2 or compatible microcomputer, with minimum 360KB RAM;
IBM colour graphics board, or EGA or VGA or Hercules compatible board;
Hard disk and math coprocessor recommended but not required.

Price:
US$40

References:

Pindor, A. "Dynamical Software or Chaos on Your Computer" *ComputerNews*, January/February 1989, #252

Pindor, A. "More Chaos on Your Computer" *ComputerNews*, October 1989, #258

Pindor, A. "PHASER–An Animator/Simulator for Dynamical Systems (for IBM)" *ComputerNews*, April 1990, #262

Pindor, A. "Chaos in the Classroom II: Fractals and Julia Sets" *ComputerNews*, July/August 1990, #264

RPlot™

A Simple and Inexpensive 2D Graphics Program

Andrzej J. Pindor
apindor@vm.utcs.utoronto.ca

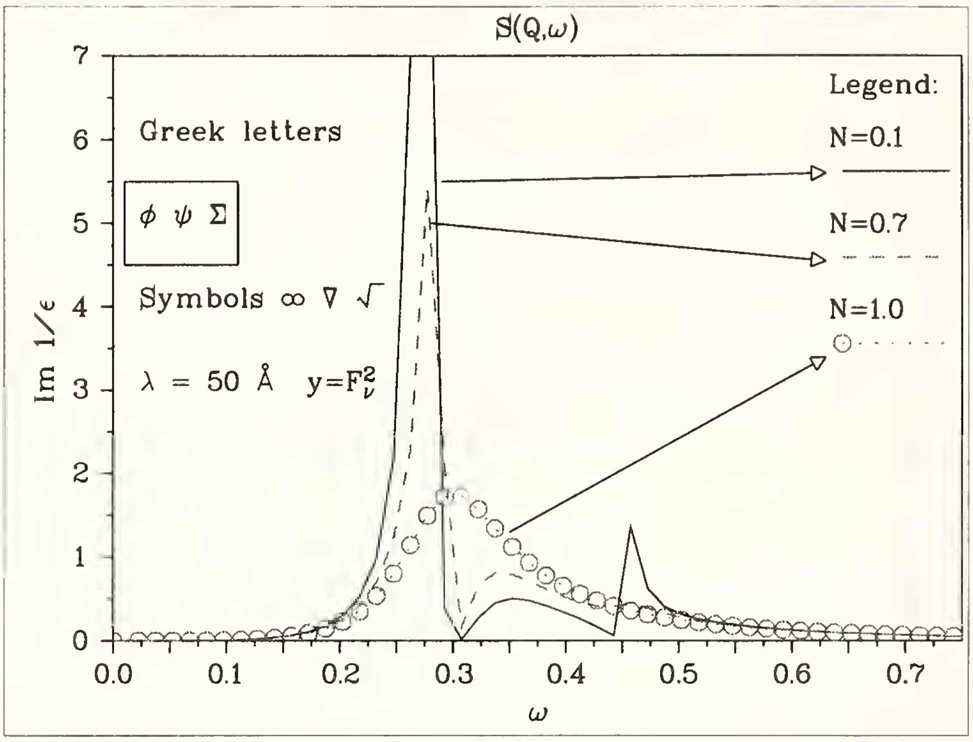

Figure 1: An example of a plot created with RPlot™.

RPlot™ is a simple and inexpensive program for creating two-dimensional (2D) plots. In spite of its simplicity, the program is surprisingly flexible. It can read data from ASCII files and create well-annotated graphs with most of the features you might need. *Figure 1* is an example of a graph created by RPlot™.

After you install the program, you execute it using the following syntax:

```
plot [plotopts]
[file[fileopts]]
```

The [file] is the name of an ASCII file containing the data to be plotted. The [plotopts] (i.e., plot options) are options that apply to the overall plot (e.g., axis labels). The [fileopts] (i.e., file options) are options that apply to a particular data file (e.g., file format). You can, in fact, plot data from several files by specifying their names in succession. In the simplest case you can plot your data simply by typing `plot filename` and pressing <Return>. The plot appears on the screen almost immediately. Pressing any key sends you back to DOS, where you can modify the command to improve the appearance of the plot. To facilitate this process, RSoft™ Inc. provides on the distribution diskette a program called **RCommand**. RCommand is a small memory-resident utility that allows you to edit the DOS command line, as well as recall the past ten commands you have typed.

Creating a satisfactory graph usually requires several iterations, but since drawing a plot is quite fast with RPlot, the process of getting it right is fairly quick. There are 51 points for each curve in *Figure 1,* yet the plot took only 14 seconds on a Zenith 286 running at six megahertz (MHz). After spending about half an hour reading through the 32-page manual, I spent approximately 15 minutes creating the graph in *Figure1.*

When a graph becomes complicated and involves many data files, the RPlot™ command becomes very long and may not fit within the DOS limit of 128 characters. This was the case with *Figure 1*. Consequently, I created a plot commands file (with the extension .PCS). This is an ASCII file that contains the entire RPlot™ command, except the word "plot." You can use any ASCII editor for this purpose. You can break the command over several lines, at the beginning of any option or file specification for readability, and you can also have comment lines. For example, the graph in *Figure 1* was created using the following command file:

```
!This is the first comment line
!the line below specifies font - Roman
/ft2
!next line sends output to
!metagraphics file aqplot1.cgm
/pm"aqplot1.cgm"
/xl"&w"/yl"Im 1/&e”/w0,0.75,0,7/tt"S(Q,&w)"/12
!the following line creates arrows
/ao0.29,5.5,0.63,5.6/ao0.28,5.0,0.63,4.55
/ao0.35,1.3,0.63,3.4
/t"Greek letters":0.025,6.0
/t"&f &y &S":0.025,5.0
!next two lines create box around Greek letters
/ln0.01,5.5,0.11,5.5/ln0.11,5.5,0.11,4.5:15,7
/ln0.01,4.5,0.11,4.5
/ln0.01,4.5,0.01,5.5:15,7
/t"Symbols &8 &11 &15":0.025,4.0
/t"&l = 50 &1 y=F_&n#^2":0.025,3.0
d:\mcad\aq2r03.prn/ny3/st15/lt”N=0.1"/st15
/lt"N=0.7"/st1/lt"N=1.0"
```

The graph specified by this file may be created by giving the command `plot @aqplot` where the name of the command file is aqplot.pcs.

When you are satisfied with the appearance of your plot, you can perform a screen capture (screen dump) and send it to directly to an Epson-compatible printer, or insert a command which will send the plot to an HP colour pen plotter. You can also redirect Hewlett Packard Graphics Language (HPGL) commands to a specified plot file, or create a computer graphics metafile. *Figure 1* was reproduced from an HPGL file. Online help is available by executing the plot command by itself. This produces a brief series of help screens which summarize how to use RPlot™ in general, and also list the most common options.

In conclusion, if all you need are well annotated 2D plots, RPlot™ may be the program just for you. It is inexpensive, simple to use, fast, and flexible. If you would like to try this program, please call Andrzej Pindor at 978-5045.

Vendor:
RSoft, Inc.
Research Software
345 Riverside Drive, Suite 2G
New York, NY 10025
USA
(212) 666-0959

Hardware Requirements:
MS-DOS computer - IBM PC, XT, AT, PS/2 or compatible
CGA, EGA, VGA, IBM-8514 colour displays or Hercules monochrome display.

Price:
US$75

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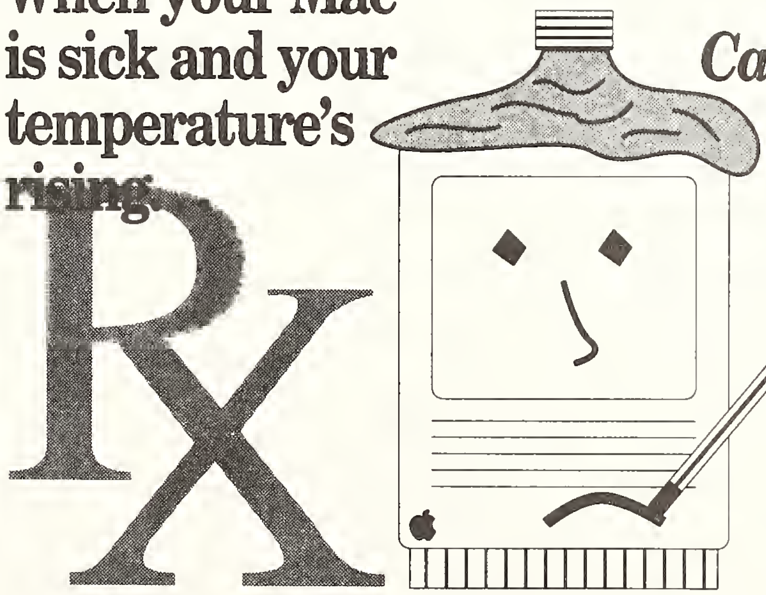

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- Computer Science interactive access
- SUN UNIX 4.0.3

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  - •Sidney Smith (Rm. 1071): 23 NEC PCs
  - •Trinity College (Rm. 024) 3 NEC PCs
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- introductory computer science

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  - •Sidney Smith (Rm. 2105): 20 DEC VT1000s, 10 DEC 2100s
  - •Departmental use: 3 DEC VT1000s

Public Sites
- 50 XT100 terminals connected to PACX
  - •Robarts Library (Rm. 1061A): 24 terminals
  - •Engineering Annex (Rm. 107B): 12 terminals
  - •St. Michael's College (Rm. 107): 9 terminals
  - •Victoria College (1st floor): 3 terminals
  - •Trinity College (Rm. 024): 2 terminals

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- solid state disk (SSD) with 64 megawords of storage
- UNICOS 5.1.11 operating system
- VAX 8350, MicroVAX II, VAXstation 3200, and SUN-3/280 provide front-end services

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- CMS timesharing system, VM/SP Release 5
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- provides access to NetNorth (BITNET), the North American Universities Network; ONET, the Ontario Regional Network; CA*net, the Canadian National Network; and USENET, the UNIX networking fraternity
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  - selection consulting for hardware and software
  - Micro Lab for evaluation of hardware and software
  - advice on University discounts
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Account & Access Code Enquiries	Phillip Mun	BC101B	978-7148
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BC = Bancroft Building
ER = Erindale
MP = McLennan Physical Labs

* NetNorth/BITNET/EARN

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Erindale College (Erin), 828-5339, 3359 Mississauga Road North, Erindale Campus, Rooms 2037, 2039A-B-C, 2045
Ramsay Wright, 25 Harbord St., Rooms 211, 213
Robarts, Robarts Library, 130 St. George St., Room 1061A
Sidney Smith (Sidney), 100 St. George St., Room 1071, 2105
St.Michael's College, 121 St. Joseph St., Room 107
Trinity College, 6 Hoskin Ave., Room 024
Victoria University, 73 Queen's Park Cres., 1st floor

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EA	24 hrs	24 hrs	24 hrs	24 hrs	None	978-HELP for Research
Erin (2039)Δ	9:00-17:00	9:00-17:00	12:00-16:00	12:00-16:00	Research	Rm 2005
(2045-46-47)	24 hrs	24 hrs	24 hrs	24 hrs	Undergrads	Rm 2005
(235)†	8:00-22:00	8:00-17:00	closed	closed	None	Rm 2046
Ramsay Wright	7:00-21:00	7:00-18:00	closed	closed	Undergrads	No
Robarts	8:30-24:00	8:30-24:00	9:00-22:00	13:00-22:00	None	978-HELP for Research
Sidney	7:00-24:00	7:00-24:00	7:00-24:00	7:00-24:00	None	978-HELP for Research
St.Michael's	24 hrs	24 hrs	24 hrs	24 hrs	None	978-HELP for Research
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Legend

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Ramsay Wright			Y	Y**
Robarts	Y	Y		Y*
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